Le temps des robots

Pour Daniel McCleese, responsable scientifique de l'exploration martienne au JPL, cela ne fait pas l'ombre d'un doute. La Nasa continuera en 2009 et au-delà *"d'aller chercher des échantillons sur Mars"*. *"Et quelle que soit la tournure que prendront les choses,* poursuit-il, *nous aurons besoin de robots mobiles. Même si nous envisageons déjà de lâcher, durant la descente des atterrisseurs, des petits avions capables d'explorer un vaste périmètre autour du site d'atterrissage, les robots auront un rôle clé à jouer. D'où la nécessité de renforcer leurs performances dans tous les domaines."*

Le maître mot, c'est l'autonomie. Conçus sur la base de l'expérience acquise avec Mars Pathfinder, les futurs véhicules utiliseront dans un premier temps, pour se déplacer, des repères identifiés sur des images faites par l'atterrisseur. Plus tard, ils seront en mesure de faire la même chose grâce à leur propre système d'imagerie stéréo. Les scientifiques sélectionneront alors des repères et des cibles, et c'est l'ordinateur du robot qui déterminera le meilleur chemin pour atteindre l'objectif.

Les performances de ces futurs robots se jugeront ainsi à leur capacité à transporter, depuis un atterrisseur, des instruments sophistiqués et à collecter des données sur les roches et le sol dans des zones parfaitement vierges.

Autant de défis technologiques que la Nasa a choisi d'affronter par étapes. En 2001, le rover Marie Curie ne sera rien d'autre que la doublure de celui de Mars Pathfinder avec, pour seul équipement, un instrument d'analyse des roches, enrichi d'une foreuse capable de prélever de minuscules carottes.

Les choses plus sérieuses commenceront en 2003. Le rover sera plus lourd (une soixantaine de kilos) et ressemblera déjà, selon Daniel McCleese, à *"un laboratoire mobile"*, avec caméra, bras articulé, mini-foreuse et instruments d'analyse. *"Il procédera à une centaine de carottages"* jusqu'à 5 cm de profondeur, afin *"de recueillir des échantillons protégés des ultraviolets ou des agressions chimiques de surface"*. Autre ambition de la Nasa, tenter dès 2003 des sondages plus

les traces qu'ont pu laisser, à la surface de la planète rouge, les grands épisodes de son passé climatique.

Le rover fera des allers et retours en pétales pour sélectionner un kilo de roches

Mars Polar Lander suivra entre le 3 et le 16 janvier. L'engin de 615 kg entrera directement dans l'atmosphère martienne en décembre prochain, à la vitesse de 7 km/s. Sa course sera freinée, comme ce fut le cas pour Pathfinder en 1997, par frottement atmosphérique sur un bouclier thermique, puis à l'aide de parachutes avant l'allumage de rétro-fusées pour un atterrissage en douceur. Mais avant même qu'elle n'atteigne son objectif, deux sondes, grosses comme des ballons de basket, auront été larguées vers la surface. Elles n'auront qu'une chose à faire : s'enfoncer de 2 m dans le sol et dire si celui-ci contient de la glace ou pas. Quant à Mars Polar Lander, elle réalisera une première en s'installant à la limite de la calotte glaciaire, entre 75 et 80° de latitude sud. Jamais une sonde ne s'est encore posée aussi près d'un pôle martien. Une belle promesse d'images en perspective, dévoilant des paysages pratiquement inconnus à ce jour. Pendant au moins trois mois, entre la fin du printemps et le début de l'été austral, cette petite station météo, équipée d'une caméra stéréoscopique, d'un bras télémanipulateur et d'un Lidar fourni par l'agence spatiale russe, guettera le moindre indice de changement climatique à la surface et étudiera les fluctuations saisonnières de l'eau, du dioxyde de carbone et de la poussière. Voilà pour l'édition 1998-1999.

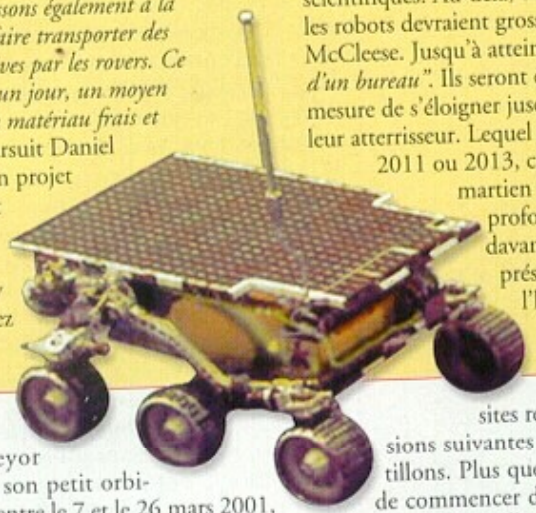
Un nouvel épisode débutera deux ans plus tard avec, comme prévu de longue date, deux sondes, une en orbite et une au sol, mais selon un scénario revu et corrigé.

1998/99
Mars Climate Orbiter : à bord, un radiomètre infrarouge pour les sondages atmosphériques (températures, poussières, vapeur d'eau) et une caméra couleur pour les images météo.
Mât support des instruments météo
Caméra stéréo. Hauteur du mât panoramique: 1,5 m
Bras robot équipé d'une caméra et d'un collecteur d'échantillons. Longueur : 2 m
Panneaux solaires
Mars Polar Lander : mini-station météo. Relevés quotidiens de température, pression, vent, vapeur d'eau. Recherche de CO^2 et de vapeur d'eau dans des échantillons de sol. Durée de vie : environ trois mois.
BAAX

profonds à partir de l'atterrisseur. *"Peut-être jusqu'à 1 m."* Auquel cas, le mobile serait appelé à jouer un rôle. Il pourrait être chargé, par exemple, d'aller chercher les prélèvements sur la foreuse de l'atterrisseur et de les déposer dans la capsule de retour.

"Nous réfléchissons également à la possibilité de faire transporter des charges explosives par les rovers. Ce pourrait être, un jour, un moyen d'accéder à du matériau frais et profond", poursuit Daniel McCleese. Un projet pour l'instant hors course. Au JPL, on estime qu'il y aura déjà assez à faire pour mener à bien les missions de 2003 et de 2005, sans qu'il soit nécessaire de se compliquer la vie avec des explosifs et les risques de contamination du sol qu'ils impliquent. En 2005, le rover sera le cousin germain de celui de 2003. Seuls différeront légèrement ses équipements scientifiques. Au-delà, en 2009 ou 2011, les robots devraient grossir, prédit Daniel McCleese. Jusqu'à atteindre *"la taille d'un bureau"*. Ils seront également en mesure de s'éloigner jusqu'à 10 km de leur atterrisseur. Lequel pourrait, en 2011 ou 2013, creuser le sol martien jusqu'à 5 m de profondeur. Faire davantage suppose la présence de l'homme.

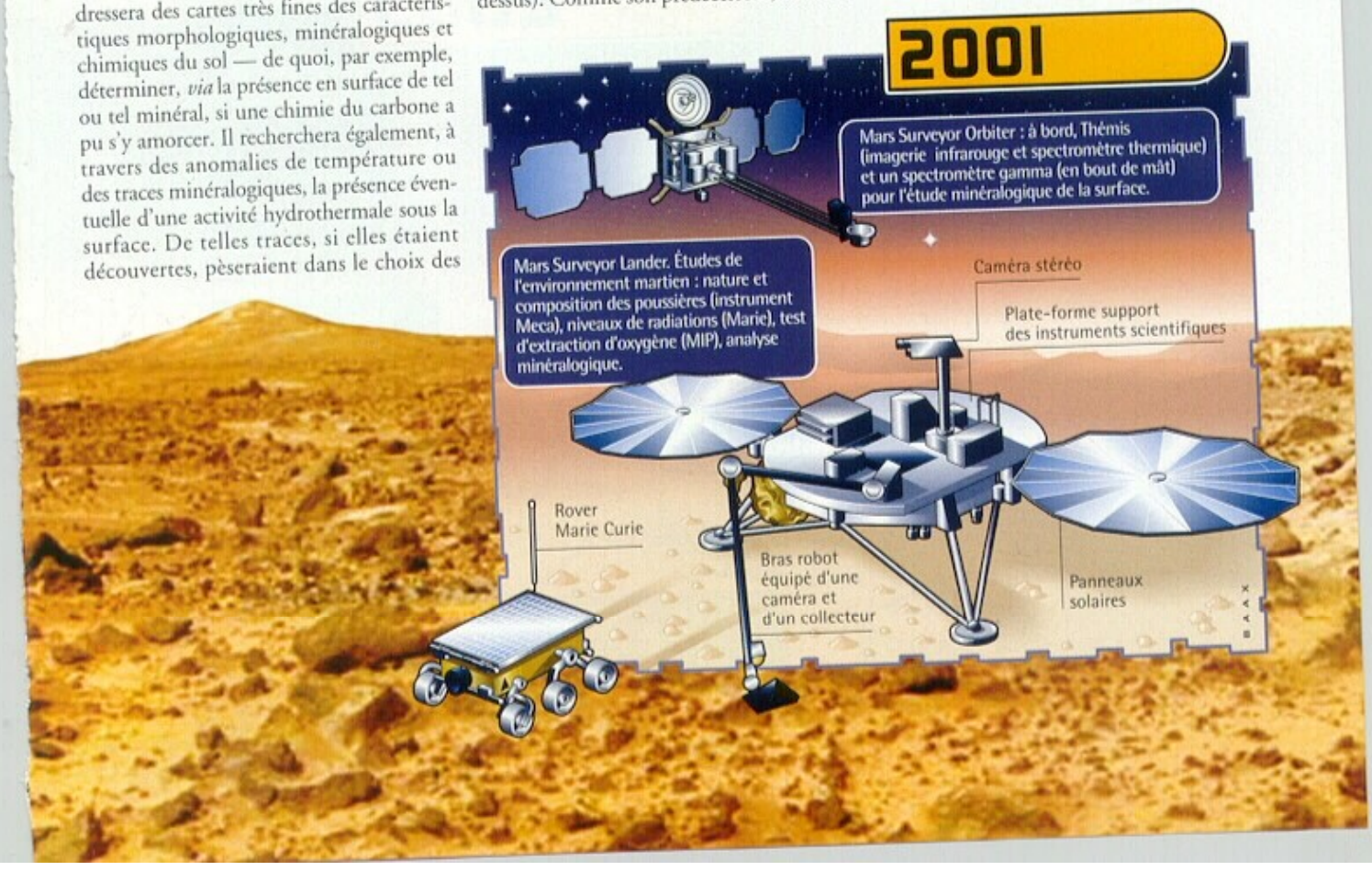
William Harwood



Photos Nasa

La mission Mars Surveyor 2001 garde son petit orbiteur. Lancé entre le 7 et le 26 mars 2001, celui-ci se mettra en orbite polaire en décembre de la même année, à 400 km d'altitude, et ce pour trois ans au cours desquels devrait être franchie une nouvelle étape dans l'inventaire que la Nasa entend dresser de la planète rouge. C'est la surface cette fois qui sera à l'honneur. Cet orbiteur dressera des cartes très fines des caractéristiques morphologiques, minéralogiques et chimiques du sol — de quoi, par exemple, déterminer, *via* la présence en surface de tel ou tel minéral, si une chimie du carbone a pu s'y amorcer. Il recherchera également, à travers des anomalies de température ou des traces minéralogiques, la présence éventuelle d'une activité hydrothermale sous la surface. De telles traces, si elles étaient découvertes, pèseraient dans le choix des sites retenus pour les missions suivantes de retour d'échantillons. Plus question, en revanche, de commencer dès cette mission les collectes d'échantillons, comme la Nasa l'avait envisagé jusqu'à présent. Plus question, non plus, de rover sophistiqué. Mars Surveyor 2001 se contentera du modèle de rechange du Sojourner emporté par Mars Pathfinder en 1996, et baptisé pour la circonstance Marie Curie (voir encadré ci-dessus). Comme son prédécesseur, ce robot de poche descendra fixé sur une petite station fixe, dont il ne s'éloignera pas de plus de quelques mètres. Avec sa caméra stéréo et ses dispositifs d'étude *in situ* des roches et de la poussière du sol, cette station de mesure sera en revanche plus sophistiquée que celle de Mars Pathfinder ou de Mars Polar Lander. Lancée entre le 5 et le 24 avril 2001, elle devrait être à poste fin janvier 2002.

Les changements sont encore plus impressionnants pour 2003. À la différence des deux épisodes précédents, l'orbiteur américain disparaît — son rôle devant éventuellement être tenu par Mars Express, la sonde que l'Agence spatiale européenne projette d'envoyer vers Mars en 2003. En revanche, c'est là que commenceront vraiment les collectes d'échantillons. Sous la coiffe d'une fusée Delta 3, la Nasa aura logé un atterrisseur emportant lui-même un rover et une petite fusée, le MAV. Ce Mars Ascent Vehicle, version miniaturisée d'un véhicule de transfert mis au point par l'US Navy dans les années 60, est destiné à placer en orbite martienne des échantillons récoltés à la surface. Le rover sera équipé de l'ensemble d'instruments baptisé Athéna que l'université Cornell avait conçu au départ pour la mission de 2001. Dans le programme initial, il devait pendant un an recueillir des échantillons sur *"au moins 10 km"*, avant de s'arrêter pour attendre la relève, en 2005 ou 2006. Trop risqué. Il se


2001
Mars Surveyor Orbiter : à bord, Thémis (imagerie infrarouge et spectromètre thermique) et un spectromètre gamma (en bout de mât) pour l'étude minéralogique de la surface.
Mars Surveyor Lander. Études de l'environnement martien : nature et composition des poussières (instrument Meca), niveaux de radiations (Marie), test d'extraction d'oxygène (MIP), analyse minéralogique.
Caméra stéréo
Plate-forme support des instruments scientifiques
Rover Marie Curie
Bras robot équipé d'une caméra et d'un collecteur
Panneaux solaires
BAAX

contentera d'effectuer des allers et retours "en pétales" autour de l'atterrisseur, où il viendra déposer, par petites quantités, le kilo de roches sélectionnées lors de ses courts trajets. Il parcourra ainsi plusieurs kilomètres au compteur, mais son rayon d'action sera limité à quelques dizaines de mètres autour de sa base.

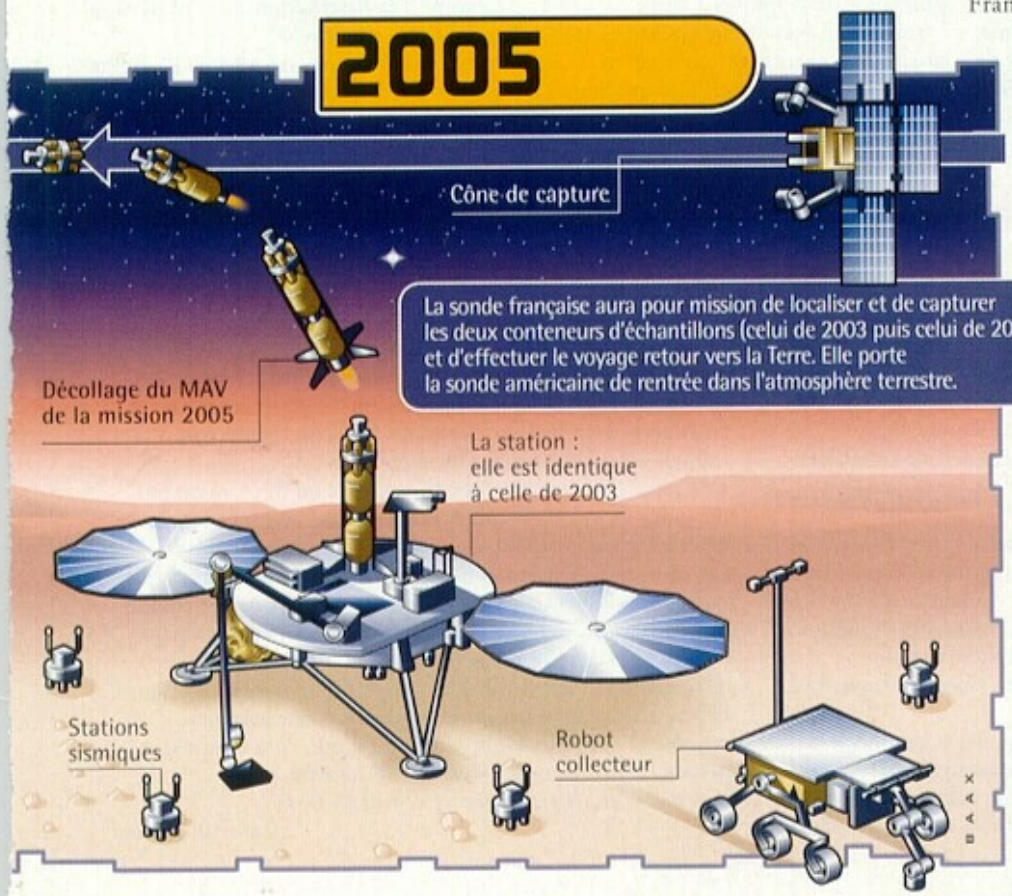
Plusieurs raisons expliquent ce chamboulement opéré durant l'été dernier par une équipe du Jet Propulsion Laboratory (JPL), le centre de la Nasa responsable de l'exploration planétaire. D'abord, l'agence américaine s'est aperçue qu'elle était en train de mordre la ligne rouge qu'elle s'était fixée en matière budgétaire (200 millions de dollars par an, en moyenne, sur dix ans). Ensuite, le robot qu'elle envisageait pour 2001 était bien plus difficile à réaliser que prévu. Enfin, et surtout, elle avait l'opportunité de s'adapter à une proposition française qui lui laissait entrevoir de substantielles économies tout en améliorant le retour scientifique des missions. *"Tout a commencé il y a environ un an"*, raconte Christophe Sotin, directeur du Laboratoire de géodynamique et de planétologie à l'université de Nantes et président du "groupe Système solaire" au Cnes. Lors de sa visite, en octobre 1997, à Paris, Daniel Goldin, le patron de la Nasa, avait en effet demandé à nouveau au gouvernement français de fournir une Ariane 5 pour le programme martien de la Nasa. *"Une requête formulée deux ou trois ans plus tôt, sans grande réaction de Paris."* Elle trouve un écho plus favorable à la fin 1997. D'une part, le Cnes se cherche un grand programme pour l'après-2000 et dispose d'un budget pour cela. D'autre part, Claude Allègre, le ministre chargé de l'Espace, est très intéressé par l'exploration planétaire et entend affirmer la particularité française au sein de l'Europe spatiale.

Des chiffres qui donnent la mesure de l'effort décidé par la France

Les choses, dès lors, vont aller très vite. En février, le JPL vient à Paris présenter son projet "Retour d'échantillons", qui sera étudié par les chercheurs français réunis à Arcachon le mois suivant afin de préparer le programme scientifique spatial des années à venir. En juillet et en août, un groupe de travail se réunit à Pasadena (Californie). En font partie côté Cnes Jacques Blamont, conseiller auprès de la direction, Richard Bonneville, directeur des programmes, Francis Rocard, responsable de l'exploration planétaire, Michel Courtois, directeur du centre toulousain, plus particulièrement chargé des évaluations techniques, et des scientifiques français.

La remise à plat est assez radicale. *"Le programme initial était axé presque exclusivement sur l'exobiologie*, explique C. Sotin. *De notre côté, nous estimions qu'il était impossible de dissocier l'apparition éventuelle de la vie sur Mars de l'évolution globale de la planète, un domaine d'autant plus intéressant qu'il est de nature à nous faire mieux comprendre comment la Terre fonctionne."* Ce choix de l'exobiologie par la Nasa était guidé essentiellement par des considérations médiatiques, le but étant d'accrocher le public américain pour amener le Congrès à accorder les financements nécessaires. Une contrainte que l'apport financier de la France devait en partie lever. Le Cnes a en effet décidé d'affecter près de deux milliards et demi de francs à ce programme. La Nasa, de son côté, dispose de deux milliards de dollars sur dix ans pour l'exploration martienne. Des chiffres difficilement comparables si l'on ne tient pas compte des salaires et des différences de coût d'un côté et de l'autre de l'Atlantique, mais qui donnent la mesure de l'effort décidé par la France : *"Notre participation*, souligne Francis Rocard, *dépasse largement 20 % de l'ensemble"*. Selon des calculs officieux effectués par les experts américains, l'économie pour l'agence spatiale américaine atteindrait environ 710 millions de dollars.

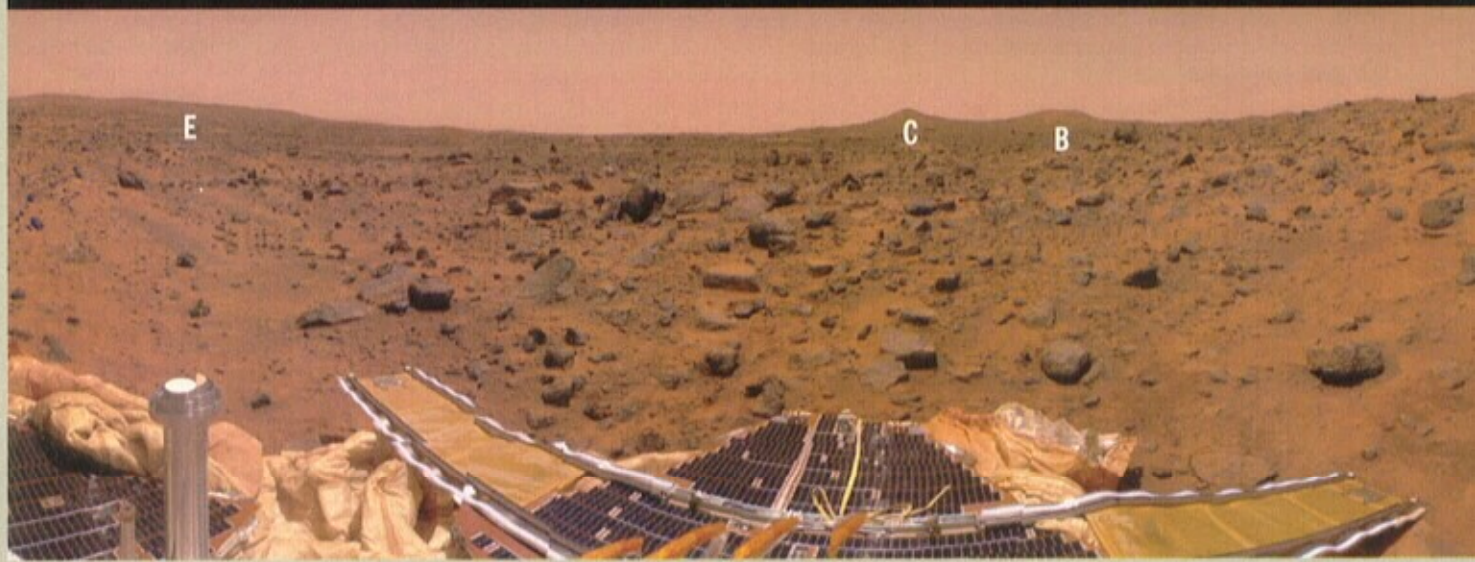
La France fait donc une entrée en force dans l'exploration martienne. Si tout se passe comme prévu, elle occupera même une position clé dans la mission Mars Surveyor 2005, point d'orgue du nouveau plan de la Nasa, avec la première tentative jamais faite de rapporter un peu de Mars sur Terre. Le Cnes fournira le lanceur, une Ariane 5. Sensiblement plus puissante que la version qui vient de réussir son entrée en service, celle-ci emportera 5 tonnes vers la planète rouge. De quoi expédier en un seul tir, et pour 800 millions de francs, la totalité du matériel — sonde, station au sol et autre robot nécessaire à l'expédition. Premier "client" important de cette Ariane 5 : une sonde de 2,7 tonnes, autre grosse participation française. Destinée à se satelliser autour de Mars, elle assurera le voyage du retour et portera, accrochée à son flanc, la capsule de fabrica-

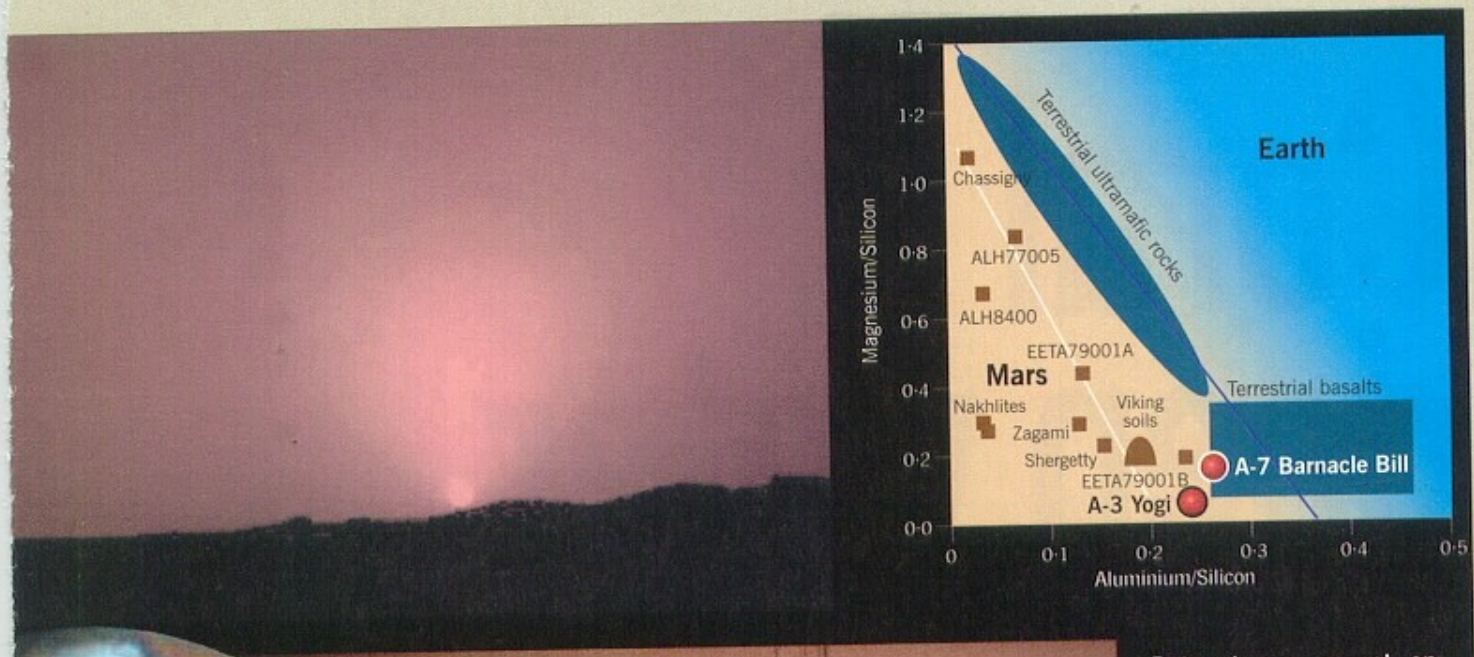

2005
Cône de capture
La sonde française aura pour mission de localiser et de capturer les deux conteneurs d'échantillons (celui de 2003 puis celui de 2005) et d'effectuer le voyage retour vers la Terre. Elle porte la sonde américaine de rentrée dans l'atmosphère terrestre.
Décollage du MAV de la mission 2005
La station : elle est identique à celle de 2003
Stations sismiques
Robot collecteur
BAAX

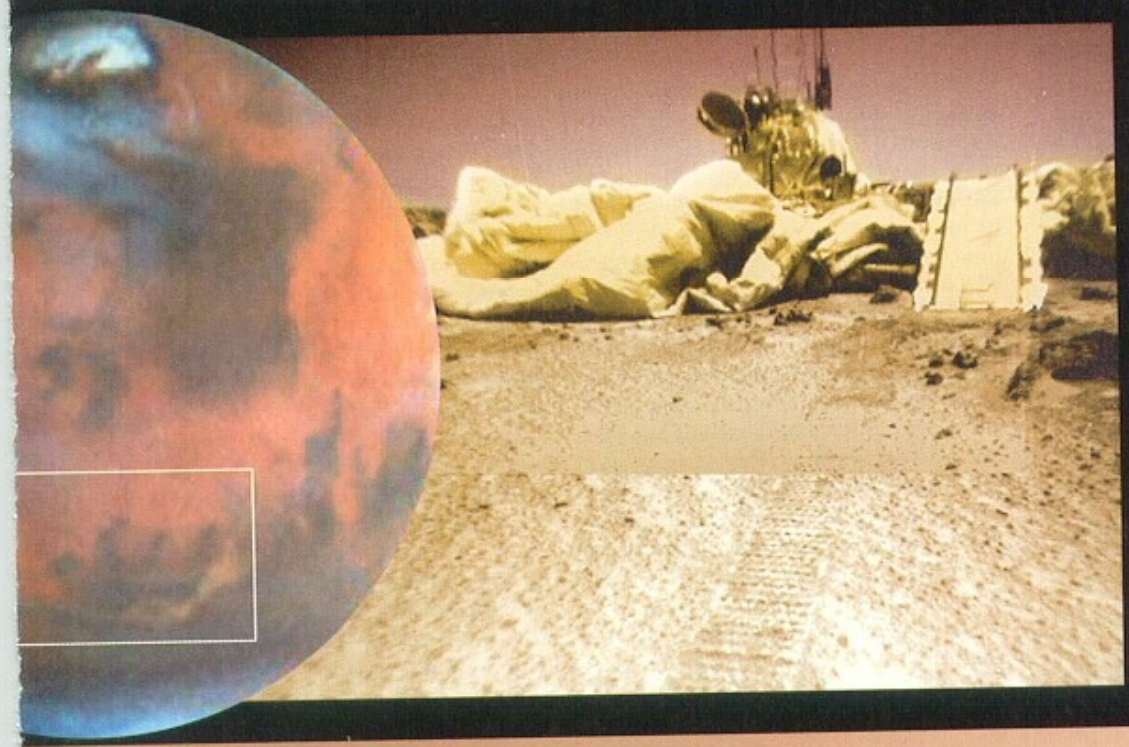
Postcards from another planet

For the price of a Hollywood movie, Pathfinder has given us stunning pictures of an alien world

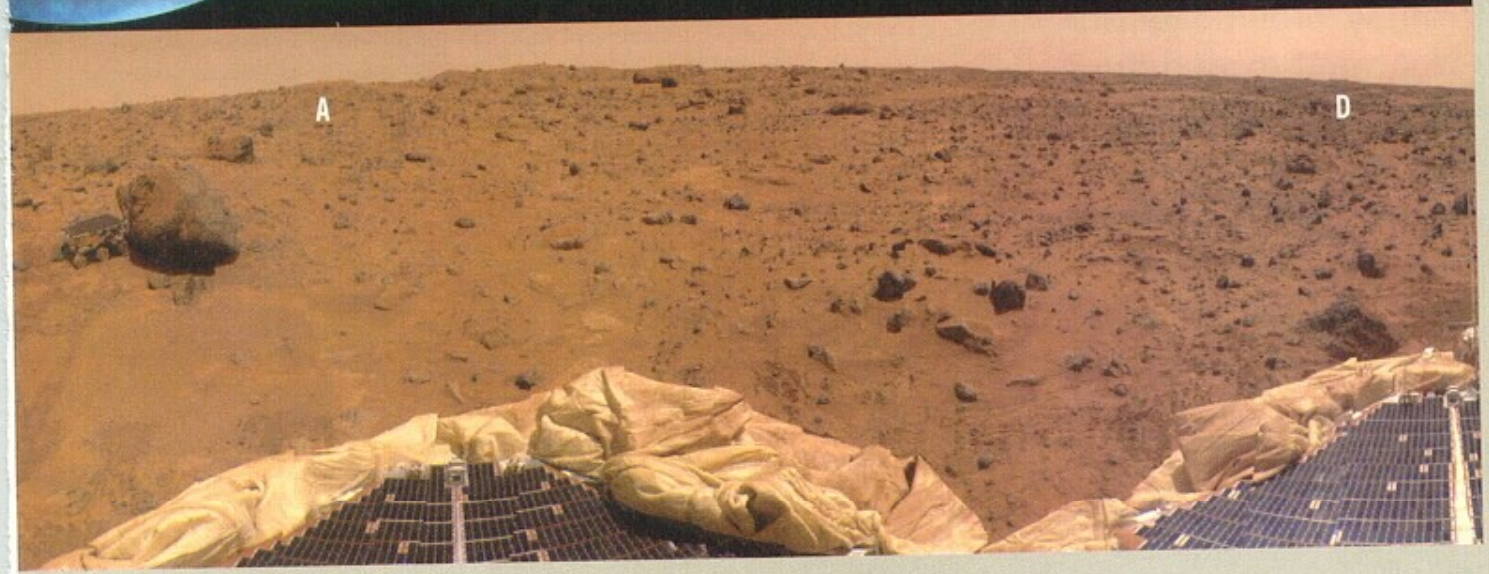
Zooming in: one week before touchdown, the Hubble Space Telescope spots a sandstorm (the yellow coloration) developing a few hundred kilometres south of the landing site (green cross). On 4 July, Pathfinder touches down sending back spectacular images of the surface. Nearby features (A,B,C,D,E) can even be matched with an overhead view of the landing site taken by Viking in the 1970s. Fears that the sandstorm would spread prove unfounded although the weather could yet turn nasty



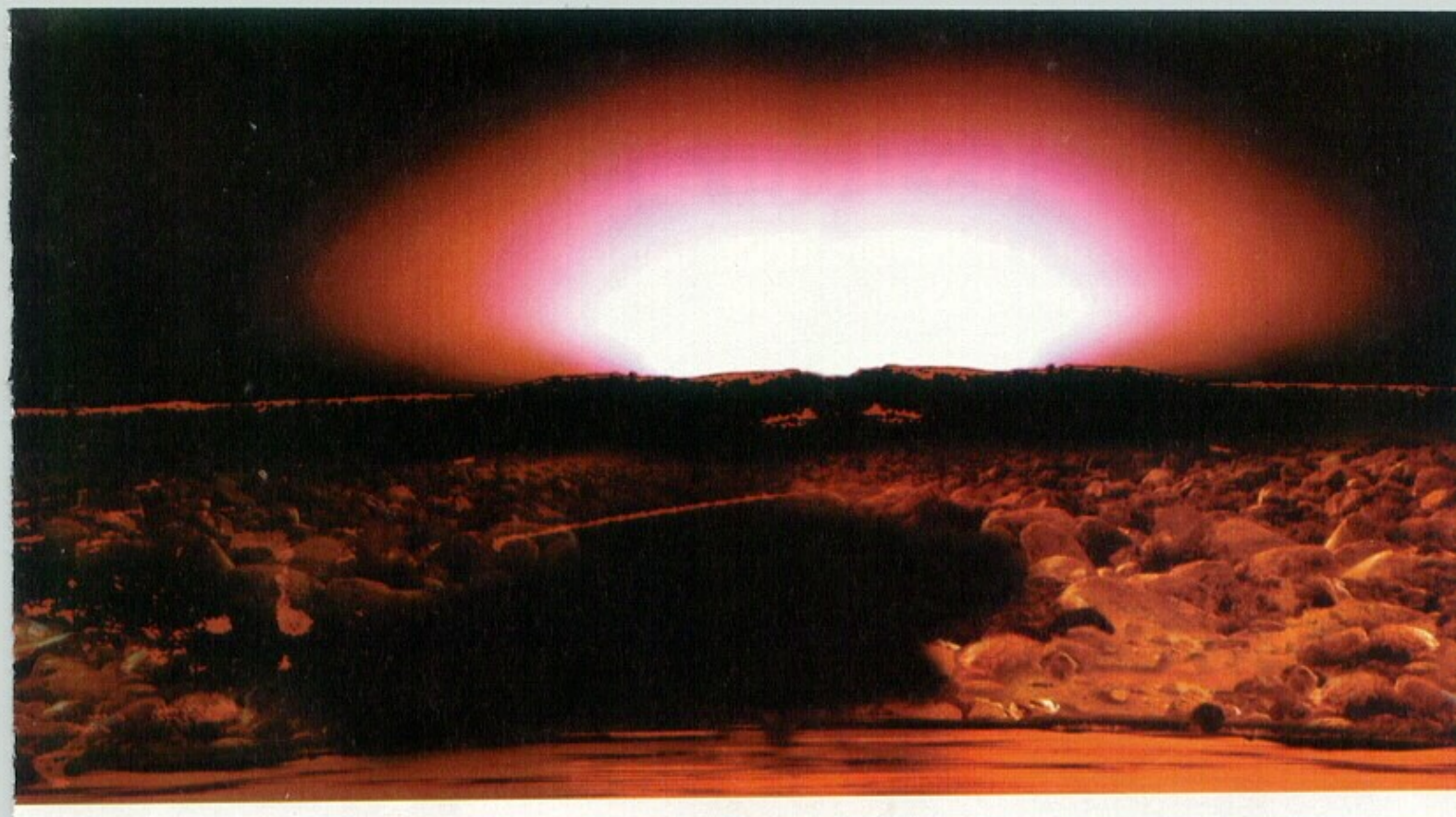




Data stream: sunset on Mars (above left) turns out to be just as spectacular as on Earth. The colour of the sky can help scientists work out the size of particles in the atmosphere. The rover, Sojourner, has photographed the lander (left) and analysed rocks nearby (above). The results are surprising. Two nearby rocks, Yogi and Barnacle Bill, are much more similar to Earth rocks than either the soils analysed by Viking or the Martian meteorites found on Earth (designated ALH..., EETA... or by the names of the places where they were found)



NASA/JPL



abundance shows how fast the atmosphere has escaped in the past.

The mission will also test a pair of torpedo-shaped "penetrators", which will be dropped before the main lander enters the atmosphere. Each weighs about 2·5 kilograms and is protected from burning up by ceramic heat shields. They will hit the ground 100 kilometres north of the MVACS lander site at a speed of about 190 metres per second—enough to bury the penetrator to a depth of up to 2 metres.

Each will carry an accelerometer to record the atmospheric drag and the impact with the surface. This will tell researchers whether the surface is layered. A small drill will scrape a sample of soil into a thimble-sized metal cup. This will then be heated and a tiny spectrometer the size of a postage stamp will look for any water that is produced.

None of this information can be transmitted back to Earth from beneath the surface, so the tail of each penetrator is designed to detach on impact and reel out a cable connected to the main body. The tail carries a pressure sensor and small antenna which will radio the data to the Mars Global Surveyor spacecraft orbiting above. With pressure sensors on each penetrator and the lander, it may be possible to monitor the passage of storm systems over the surface.

Penetrating insights

The penetrators should continue working for a couple of days, and maybe longer, if their batteries survive the impact. It's a big "if"—the penetrators will strike the surface with a force equivalent to 80 000 times their weight here on Earth. No penetrator has successfully reached another planet or moon. The Japanese space agency ISAS plans to send penetrators to the Moon next year and the Russian space agency's Mars 96 mission carried two, but they were lost along with the rest of the mission when its booster misfired. While the latest attempt may provide valuable data, its main objective is to show that penetrator technology works.

Meanwhile, the MVACS lander should continue collecting data for much longer, up to seven months during the Martian summer in 1999. During that time it should provide vital clues to the planet's cause of death. But as winter sets in and the Sun sinks low on the horizon, MVAC's solar panels will stop producing power to operate the lander. As CO_2 frost begins to form around it, MVACS will fall silent.

But this may not be the end. Scientists hope that the following spring, almost 400 days later, MVACS will come back to life. By that time, the next salvo of Mars missions will be on its way. □

Ralph Lorenz is a research associate at the University of Arizona. He models climates throughout this and other solar systems and is working on the TEGA experiment

Further reading: the MVACs home page is at **http://mvacs.ess.ucla.edu/mvacs/index.html**

20 July 1976

Viking 1 touches down on the surface armed with a set of experiments to search for signs of life. The mission is a huge success but it is accidentally shut down on 13 November 1982 and communications are never re-established

2 September 1988

The Soviet spacecraft Phobos 1 is lost en route due to a command error. It had been due to place a lander on the Martian moon of the same name

21 August 1995

NASA's $1 billion Mars Observer vanishes as it approaches Mars

16 November 1996

The Russian Mars 96 spacecraft crashes back to Earth soon after launch

4 July 1997

Mars Pathfinder lands on Mars and deploys the Sojourner rover—the first vehicle to be deployed on the surface of another planet. It is the first successful mission to Mars for 20 years

12 September 1997

The Mars Global Surveyor arrives at Mars

USA, France, Europe

Alors que Mars Global Surveyor, en poste depuis plus d'un an, se prépare à un survol rapproché, deux nouvelles sondes sont à leur tour en partance pour la planète rouge. Ce n'est encore qu'une avant-garde mais elle annonce la grande offensive de la Nasa, qui culminera en 2005 avec la première tentative pour rapporter sur Terre une poignée de cailloux et de poussières. Une aventure où la France vient de faire une entrée en force.

La ruée vers Mars

Jean-Paul Dufour et Jean-Pierre Defait

Photos Nasa

LA Nasa avait promis de bombarder Mars à raison de deux sondes tous les deux ans. Elle tient ses engagements. Alors que Mars Global Surveyor (partie le 6 novembre 1996, un mois avant Pathfinder) entamera dans quelques semaines une cartographie détaillée de la planète rouge, la première vague de cette grande offensive martienne est en route. En tête, Mars Climate Orbiter. La sonde de 633 kg devait être lancée par une fusée Delta 2 entre le 10 et le 17 décembre dernier, pour une arrivée autour de Mars en septembre prochain. Placée sur une orbite quasi polaire, à 400 km d'altitude, elle dressera pendant deux ans la carte du climat et de ses variations saisonnières. Cet intérêt pour la météo martienne n'est pas nouveau. Un des principaux instruments embarqués sur Mars Climate Orbiter était déjà présent sur Mars Observer, cette sonde perdue par la Nasa alors qu'elle abordait la planète rouge, en août 1993. Objectif : sonder l'atmosphère et mesurer ainsi aussi bien les variations de température que les concentrations de poussières, de gaz carbonique ou de vapeur d'eau. Mais figure également au menu de ces deux années d'observation l'étude des nuages, du régime des vents et de leur rôle dans l'érosion de la surface, avec une attention toute particulière pour les célèbres tempêtes de poussières qui affectent régulièrement la planète rouge. Enfin, les astronomes espèrent retrouver, grâce aux images de Mars Climate Orbiter,

Quel site, et pour quoi faire ?

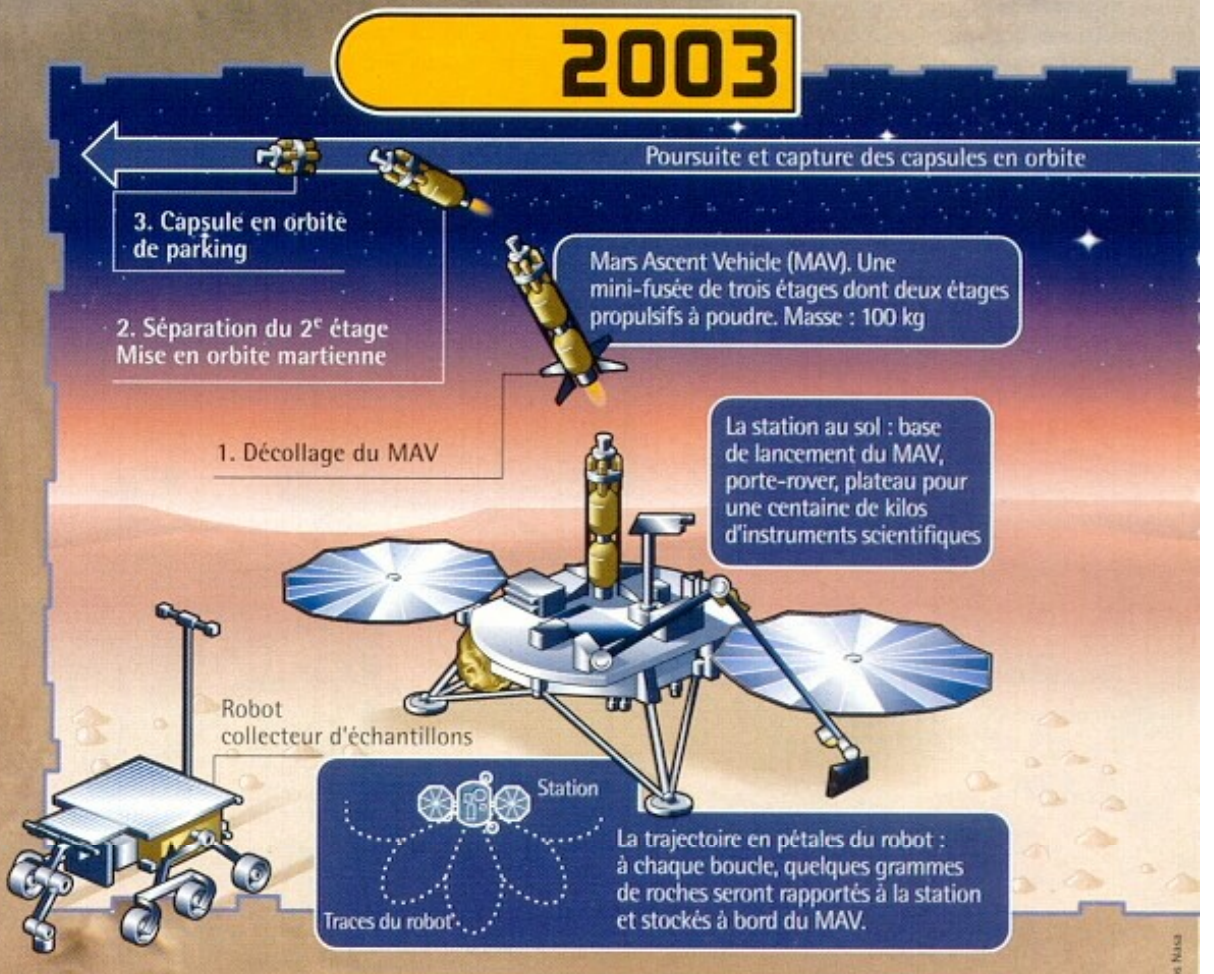
Exobiologistes, géochimistes et spécialistes de l'atmosphère ne rêvent pas des mêmes cailloux martiens. Pour les premiers, l'échantillon parfait est un sédiment, un calcaire par exemple, qu'il faudrait aller chercher à 1 m de profondeur dans des dépôts lacustres ou dans un ancien lit de rivière. *"Les éventuels micro-organismes présents dans l'eau ont pu être piégés dans ces roches"*, explique André Brack, du Centre de biophysique moléculaire d'Orléans. Un échantillon ayant été en contact avec une source hydrothermale qui, sur Mars, aurait pu fonctionner bien après la disparition des rivières de surface leur conviendrait également. Bref, les exobiologistes veulent des roches du sous-sol ayant été en contact avec l'eau.

Une demande incompatible avec celle des géochimistes. Ces derniers cherchent avant tout à comprendre la genèse de la planète et à établir un parallèle entre Mars et la Terre. Leur intérêt se porte donc sur des roches volcaniques en provenance du manteau, des basaltes par exemple, qu'ils pourraient dater *via* la désintégration de leurs éléments radioactifs. Ils aimeraient en particulier dater les dernières éruptions volcaniques. *"Les sédiments sont constitués de dépôts de provenances diverses, qui ont été altérés, dégradés*, précise Jean-Louis Birck, de l'Institut de physique du globe. *Il n'est guère facile de les dater de cette manière. Nous fuyons les roches qui se sont trouvées au contact de l'eau."*

Alors, entre volcan ou rivière, que choisir ? *"Une solution de repli serait de recueillir d'éventuels galets drainés par les rivières. La surface de ces galets aura probablement été altérée par l'eau mais on peut espérer que leur cœur soit intact"*, reprend Jean-Louis Birck.

Les spécialistes de l'atmosphère, quant à eux, rêvent d'un échantillon de la calotte polaire. En effet, au fur et à mesure de sa formation, la glace emprisonne des bulles de gaz, dont la composition chimique est la même que celle de l'atmosphère de l'époque. De quoi ainsi retracer l'évolution du cocon gazeux de la planète rouge. Mais ne rêvons pas : les robots des prochaines missions, utilisant leurs panneaux solaires pour faire le plein d'énergie, ne pourront fonctionner qu'à des latitudes équatoriales, là où l'ensoleillement est maximal. Quant à prélever un flacon d'air au-dessus des calottes, une montgolfière ferait l'affaire, *"mais celle-ci n'est pas prévue avant 2005"*, déclare Éric Chassefière, du Laboratoire de météorologie dynamique. Unique consolation : des échantillons de l'atmosphère au-dessus de l'équateur seront prélevés et analysés sur place. Un flacon sera rapporté sur Terre. Seuls les géologues sont prêts à se satisfaire de n'importe quel site et de n'importe quelle roche. Aucun choix n'a encore été arrêté pour 2005 mais les exobiologistes sont donnés gagnants.

Azar Khalatbari


2003
Poursuite et capture des capsules en orbite
3. Capsule en orbite de parking
2. Séparation du 2e étage
Mise en orbite martienne
1. Décollage du MAV
Mars Ascent Vehicle (MAV). Une mini-fusée de trois étages dont deux étages propulsifs à poudre. Masse : 100 kg
La station au sol : base de lancement du MAV, porte-rover, plateau pour une centaine de kilos d'instruments scientifiques
Robot collecteur d'échantillons
Station
Traces du robot
La trajectoire en pétales du robot : à chaque boucle, quelques grammes de roches seront rapportés à la station et stockés à bord du MAV.

Photos Nasa

L'Europe hors jeu ?

L'Europe restera-t-elle dans la course vers Mars ? Début décembre, la question restait ouverte. Tout le monde à l'ESA semblait d'accord pour soutenir Mars Express. Plus question d'unanimité, en revanche, pour donner aux budgets scientifiques de l'agence européenne le coup de pouce sans lequel cette mission était quasiment condamnée (voir Actualité page 25).
Mars Express doit être lancée en juin 2003. À bord, une caméra à très haute résolution, un instrument de cartographie minéralogique de la surface et un laser capable de sonder le sol jusqu'à plusieurs centaines de mètres de profondeur. À quoi s'ajouterait un atterrisseur, Beagle 2, pour des expériences d'exobiologie. Autre vocation de Mars Express : servir de relais aux missions de la Nasa en 2005 et au-delà. Coût : 980 millions de francs. La moins chère des missions martiennes, jure-t-on à l'ESA.

Jean-Pierre Defait

Photos Nasa

tion américaine, qui rentrera dans l'atmosphère terrestre avec les précieux cailloux.

L'autre pièce maîtresse de la mission sera constituée d'un atterrisseur de 1,7 tonne, de son robot mobile et de sa petite fusée MAV, tous deux de fabrication américaine. Le principe est en effet de refaire en 2005 ce qui aura déjà été testé en 2003, à savoir une nouvelle collecte d'échantillons. Une deuxième petite capsule sera donc expédiée en orbite martienne. Ce sera une garantie contre le risque de tout perdre si un incident devait se produire lors de la mission de 2003. Mais ce n'est pas tout. Le choix d'Ariane 5 autorisant des largesses, il restait de la place pour loger un paquet de quatre mini-stations d'une cinquantaine de kilos chacune. Dérivées de la capsule européenne Huygens qui fait route actuellement vers Saturne avec la mission Cassini, ces mini-stations devraient procéder notamment à des sondages sismiques, à l'image de ce qui se fait pour la recherche pétrolière. On peut en attendre des informations inédites sur la structure interne de Mars et sur la présence éventuelle d'eau ou de glace dans son sous-sol.

Dans le même esprit, les Français ont insisté pour que l'atterrisseur principal ait la capacité d'analyser sur place une partie des échantillons récoltés. *"Ce sera une sécurité en cas d'échec du retour d'échantillons,* explique Christophe Sotin. *Mais surtout, nous pourrons ainsi mieux sélectionner les roches à rapporter en tenant compte des données recueillies par les orbiteurs des missions précédentes."* Enfin, ultime profit tiré de la puissance de la nouvelle fusée Ariane 5, l'atterrisseur devrait être équipé d'un dispositif de carottage capable de forer jusqu'à 2 m dans le sol. Cet instrument, dont l'agence spatiale italienne assurera la réalisation, pourrait fournir des indications intéressantes sur d'éventuelles traces de vie (fossiles ou non) susceptibles d'avoir échappé à la destruction par l'oxydation qui sévit à la surface.

On est donc loin du schéma d'origine où les récoltes d'échantillons débutaient dès 2001 et 2003. Un robot était chargé, à cha-

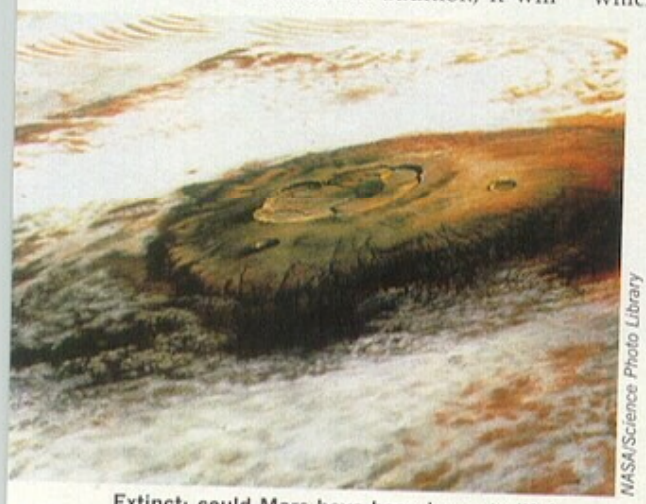
Des échantillons sous haute protection

Les échantillons martiens ont déjà leurs opposants. Des citoyens américains, inquiets des risques de pollution bactérienne que pourrait provoquer leur présence sur notre planète, se sont organisés en lobby afin de s'opposer à leur retour. Habituée à ce genre de pression, la Nasa a prévu dans le financement de son programme martien une ligne budgétaire pour payer… ses avocats. Au-delà de l'anecdote, ce risque n'est pas pris à la légère et l'agence spatiale s'est entourée d'un luxe de précautions.
Ainsi, la trajectoire de retour de la sonde la fait passer très au large de notre planète. C'est seulement lorsque les instruments de bord auront vérifié l'étanchéité du conteneur et l'absence de pollution bactérienne à bord que sa course sera infléchie sur une orbite de rentrée dans l'atmosphère terrestre.
Une fois la capsule larguée, la sonde elle-même sera renvoyée sur une orbite solaire.
Il a même été envisagé une stérilisation des échantillons par chauffage à 2 000 °C ou par irradiation gamma.
Un tel traitement ayant toute chance de réduire sérieusement leur intérêt scientifique, cette solution sera sans doute évitée.
Dès leur arrivée, les roches martiennes seront, en tout cas, placées en quarantaine dans un laboratoire analogue à ceux où sont manipulés les virus dangereux. Seule une équipe de chercheurs triés sur le volet y aura accès. Après cette période, dont la durée n'est pas définie mais qui pourrait atteindre un an selon Francis Rocard, ingénieur au Cnes, les précieux cailloux seront examinés plus librement.
Le Cnes a obtenu de la Nasa la promesse qu'il n'y aurait pas de quotas et que les Français auraient accès aux échantillons dans les mêmes conditions que leurs confrères américains.
Les chercheurs français aimeraient, en outre, être certains que quelques-uns d'entre eux feront partie de la "première équipe", qui, forcément, publiera la première étude sur ces matériaux inédits. Certains ont même suggéré qu'un laboratoire de quarantaine soit construit sur le territoire français — pour héberger les poussières, par exemple, alors que les roches resteraient aux États-Unis. Une option qui, dans l'immédiat, précise Francis Rocard, *"a été à peine abordée avec les Américains et n'a pas encore reçu l'aval du Cnes."*

Jean-Paul Dufour

the south polar cap. These formations can be traced for hundreds of kilometres and scientists believe they are made of dust and ice, laid down in layers as periods of cold alternated with warmer conditions. A record of the Martian climate may be written in the geology of the area in the same way that the climate record on Earth is reflected in ocean sediments, ice cores and tree rings.

In May 1999, MVACS will land at a latitude of 72° South, at the edge of the southern polar cap. It will study these strange layers, searching for carbonates and ice in the soil. In addition, it will monitor the seasonal CO_2 and water content of the atmosphere.



NASA/Science Photo Library

Extinct: could Mars have been home to life?

Several cameras on board MVACS will provide much of the data. First, a small descent imager will take photographs as the craft comes in to land. A stereo camera, built at the University of Arizona in Tucson and similar in design to the one carried by Pathfinder now on the Martian surface, will survey the landing site and monitor weather. MVACS also carries another camera mounted on the end of its robot arm. This will take close-up images of the soil and its layering.

The robot arm will also place samples of Martian soil in a small oven known as the Thermal and Evolved Gas Analyzer (TEGA)—a pair of small metal tubes wrapped in platinum wire heaters. The sample occupies one of the tubes, which is heated at a constant rate, along with the other, empty tube. The instrument monitors the temperature of the tubes: any deviation between them will indicate that a phase change is taking place in the sample, the melting of ice, for example, or a carbonate rock decomposing.

Any gases given off by the sample will be flushed through a laser spectrometer. This contains two tunable laser diodes, which emit infrared light over a small range of wavelengths according to the amount of current passed through them. Since gases such as water vapour and CO_2 absorb infrared light at specific frequencies it will be possible to measure how much of each is present. "One of the big mysteries of Mars is where is all the water and CO_2. TEGA may allow us to see if the soil can be where all the water and CO_2 is hiding," says Bill Boynton, a planetary scientist at the University of Arizona who leads the TEGA team.

Spotting oxygen is important too. Much of the planet's water may have been broken down into hydrogen and oxygen by sunlight. The hydrogen would have escaped into space, but the heavier and more reactive oxygen atoms may have been absorbed by the soil. There is some evidence for this already. The Viking landers found that the soil gave off CO_2 when nutrients were added. This could indicate life, but Viking also discovered that no organic molecules were present, and life without organic compounds seems unlikely. An alternative explanation is that Martian soil contains a highly reactive oxidising agent—something you might expect if it had reacted with atmospheric oxygen in the past. An oxidising soil would decompose nutrients and would destroy any other organic compounds. However, the story may be different beneath the surface, out of reach of an oxygen-rich atmosphere. If TEGA finds no oxidising agents beneath the surface, says Boynton, this might suggest that organic molecules or even microbial life could survive there.

'IN 1999, A NASA SPACECRAFT WILL LAND AT THE EDGE OF THE SOUTH POLE TO STUDY THE STRANGE LAYERED TERRAIN'

Weather eye

The lander will provide detailed weather reports. As well as pressure, temperature and wind speed sensors, the lander has a laser spectrometer to determine the composition of the atmosphere by measuring the amount of light it reflects and absorbs. One important measurement will be which isotopes of carbon, hydrogen and oxygen are present in CO_2 and water vapour. Heavier isotopes are less likely to escape into space, so their relative

A catalogue of disasters

10 October 1960

The first probe destined for Mars, the USSR's Mars 1960A, fails to reach Earth orbit, setting the trend for a long series of disastrous missions to the Red Planet. Between 1960 and 1997, 17 out of 27 missions to Mars experience some kind of failure

14 July 1965

The American spacecraft Mariner 4 becomes the first to fly past Mars returning 22 close-up photographs

24 November 1971

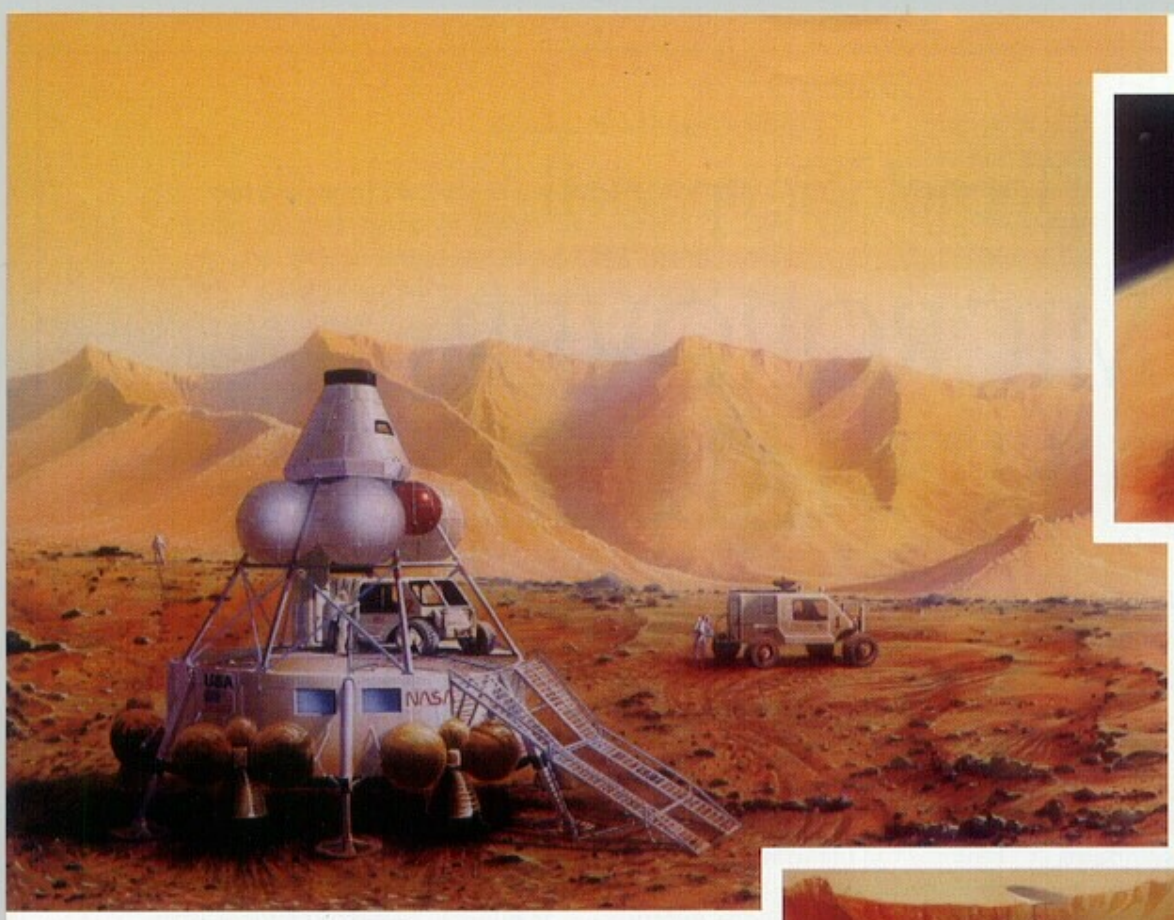
Mariner 9 takes the first high-resolution images of the Martian moons Phobos and Deimos. It also sends back images of rivers and channel-like features on the Martian surface

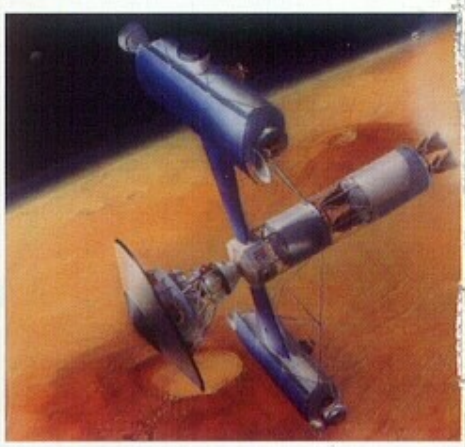
27 November 1971

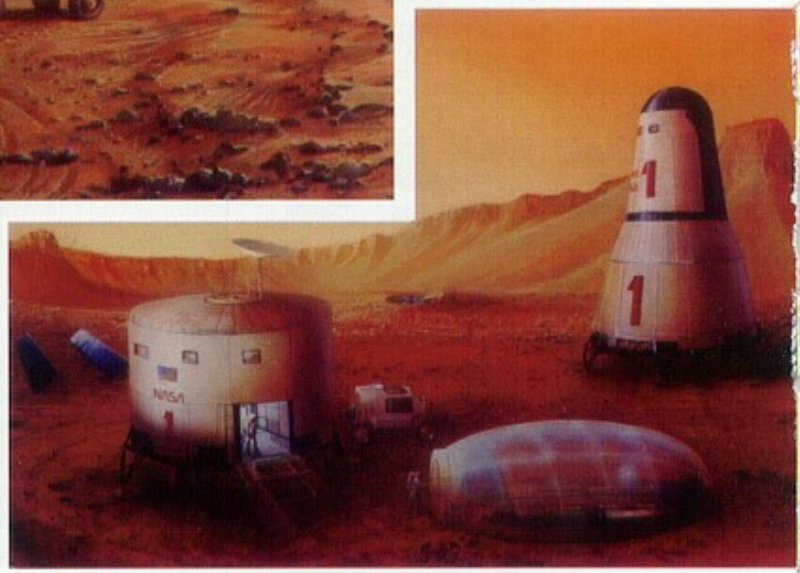
The USSR places the first spacecraft in orbit around Mars. The Mars 2 spacecraft also carries a lander but this crashes when its braking rockets fail

2 December 1971

Mars 3 becomes the first spacecraft to make a soft landing on Mars. Unfortunately, it falls silent after only 20 seconds







Profilo di una missione

Questo potrebbe essere lo schema della prima missione esplorativa umana su Marte. Sei astronauti arriveranno in orbita attorno al pianeta in un «veicolo di trasferimento» ***(in alto a destra)****. Da questo si distaccherà un «Lander» che porterà tre di essi sulla superficie; gli astronauti avranno a disposizione due veicoli per le escursioni esplorative. Il passo successivo sarà l'impianto di una base permanente* ***(a destra)****. Ma questa dovrà essere preceduta dalla realizzazione di una base simile sulla Luna.*

ne) e proteggere gli astronauti. Tutto questo significa peso e un missile ha una efficienza molto bassa: solo il 5% del peso al decollo di un Saturno 5 arrivava in orbita terrestre e circa l'1% in orbita lunare. E queste proporzioni sono valide sempre, quindi anche se si vuole mandare una sonda automatica a esplorare un altro pianeta. Portare quindi un veicolo automatico simile all'auto lunare, su Marte o su un asteroide, richiede non solo un vettore di dimensioni colossali ma soprattutto uno sforzo finanziario ragguardevole.

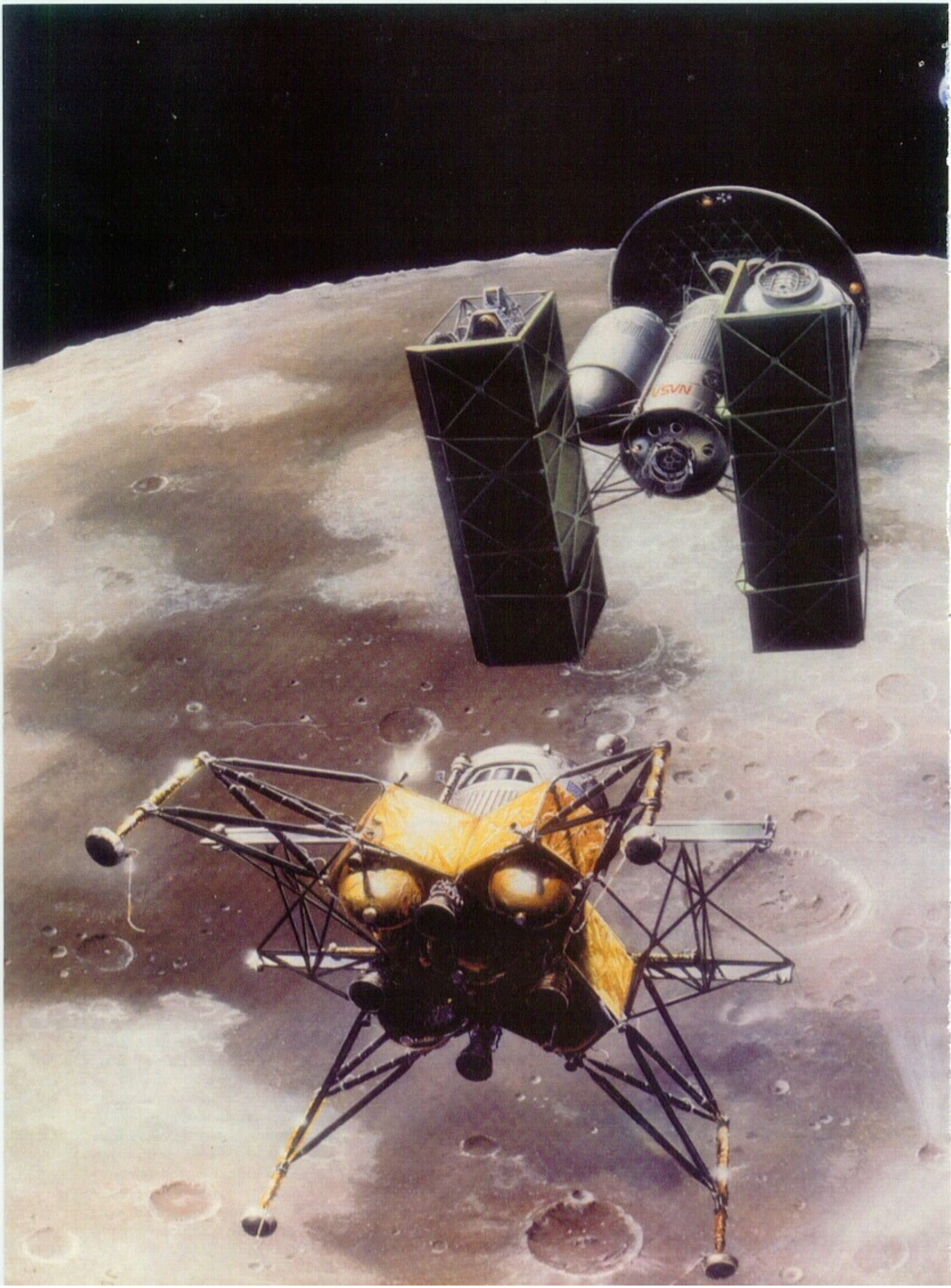
Fin dagli albori delle attività spaziali si è sempre ritenuto indispensabile procedere per gradi: l'esplorazione umana di un pianeta deve essere preceduta da una ricognizione satellitare e dall'invio di sonde automatiche in grado di spostarsi autonomamente sul suolo del pianeta. La distanza e quindi la difficoltà delle comunicazioni, o quanto meno il tempo necessario affinché i segnali arrivassero sulla Terra e potessero essere ritrasmessi dei comandi, suggerivano veicoli con un certo grado di autonomia, quindi di intelligenza artificiale. Ma si finiva per scontrarsi con i pesi e le dimensioni e pur tra mille difficoltà Marsokhod, un veicolo progettato dai russi per una missione esplorativa su Marte da realizzarsi forse nel 1996, pesa 100 kg. Sei ruote coniche, una certa autonomia decisionale e un generatore a radioisotopi per l'alimentazione elettrica, rappresenta la soluzione conservativa al problema dell'esplorazione planetaria.

Ma spesso esistono soluzioni migliori di quelle ottimali, e sono quelle dovute ad approcci cosiddetti innovativi.

Recentemente sia i francesi del CNES, l'agenzia spaziale francese, che gli scienziati del JPL, il Jet Propulsion Laboratory dell'Istituto di Tecnologia della California, hanno proposto un modo completamente nuovo di risolvere il problema. Al JPL hanno sviluppato Rocky 4, 7 kg di peso, 6 ruote e un costo di solo 2 milioni di dollari contro i 20 milioni del sovietico Marsakhod.

Il CNES invece ha allo studio un VAP, veicolo automatico planetario, caratterizzato da un telaio telescopico per adattarsi agli ostacoli. Fin dal 1989 stanno studiando dei RISP, robot d'intervento su siti planetari, con l'idea di fondo, comune anche ai progetti del JPL, di realizzare un veicolo automatico, semplice nelle strutture meccaniche, flessibile nell'uso, con una elevata autonomia grazie ad algoritmi inferenziali e adattativi che utilizzano le tecniche dell'intelligenza artificiale per quanto riguarda la visione e quindi il riconoscimento degli ostacoli.

Lo scopo è quello di svolgere ricognizioni ed esplorazioni planetarie, raccogliendo e analizzando campioni e svolgendo profili di misure.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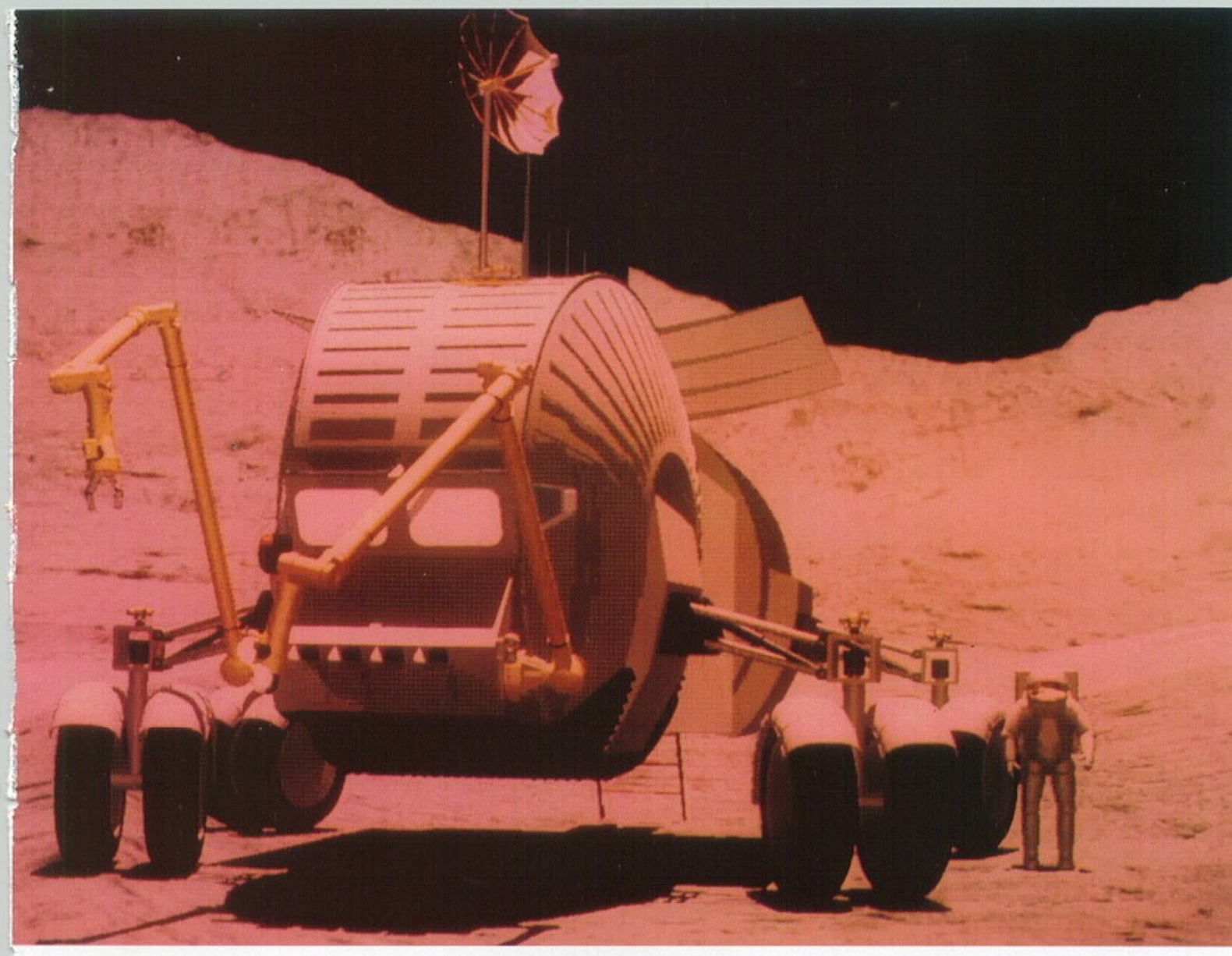
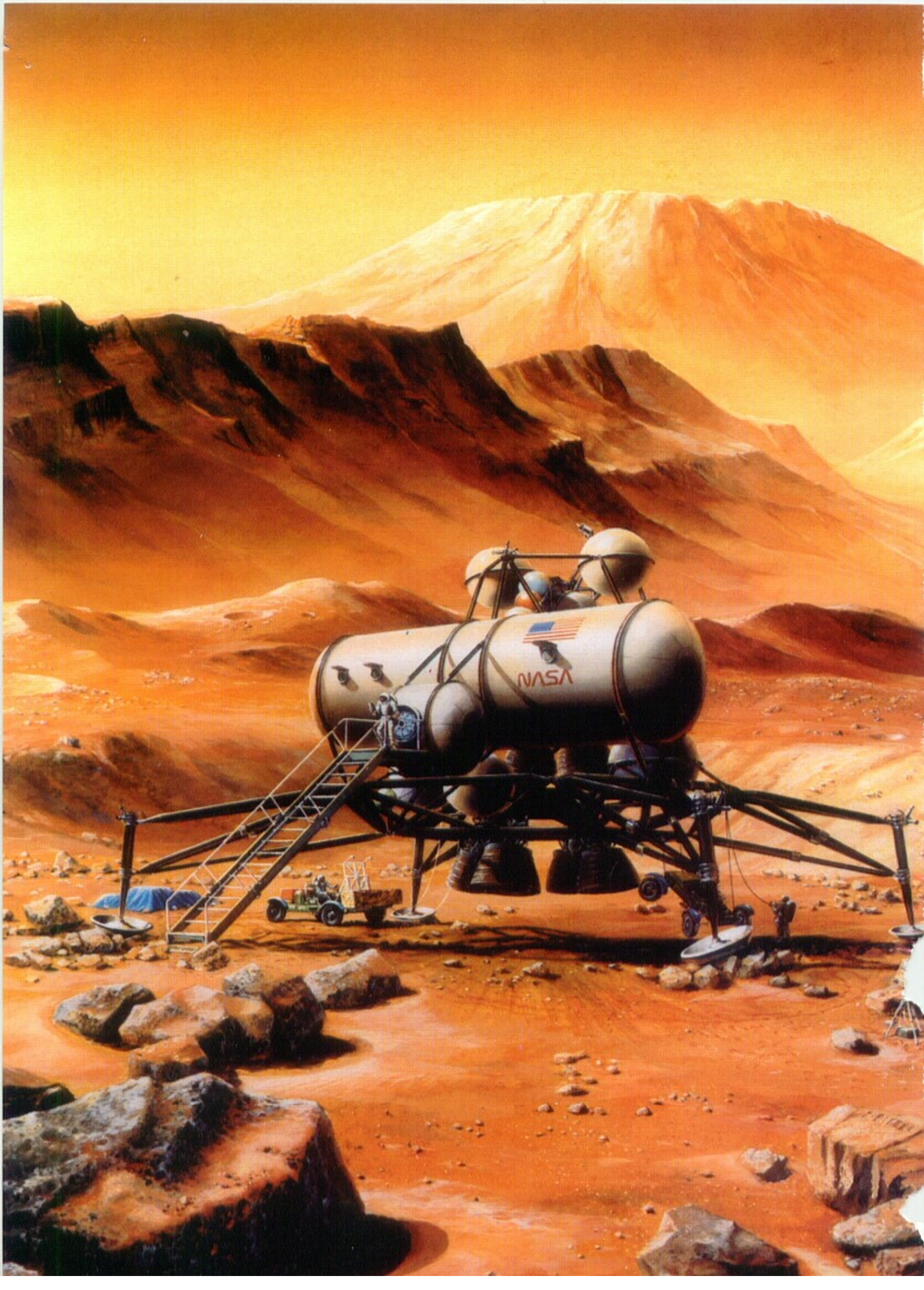


Rover planetario

Qui sopra: *la rappresentazione di un veicolo per l'esplorazione planetaria, progettato negli Stati Uniti. Verrà sperimentato sulla Luna, e in seguito potrà servire gli astronauti su Marte.*

Qui accanto: *esiste già una simulazione di quello che potrà essere il suo «posto di guida». La sua complessità è paragonabile a quella del cruscotto dello Shuttle.*

Il MIT, l'Istituto di Tecnologia del Massachussetts, va anche oltre: perché limitarsi a veicoli da 7 kg realizzati con tecnologie ancora domestiche? Passiamo alle micromacchine e realizziamo veicoli su scala molecolare del peso di pochi grammi. Quest'ultima è probabilmente solo una provocazione per attirare l'attenzione sulle potenzialità delle micromacchine e sulle loro applicazioni potenziali nella manuten-


NASA

UN PO' D'ITALIA SUL PIANETA ROSSO

Le difficoltà finanziarie e politiche dei programmi spaziali sovietici hanno favorito la collaborazione di imprese italiane alla missione MARS 94, il cui obiettivo è esplorare il "pianeta rosso".
Il progetto da lanciare alla fine del '94 è quello di una scuola automatica che atterrerebbe in uno dei "mari" marziani, e da cui si distaccherebbe un veicolo mobile che esplorerebbe un ampio territorio.
Nello sviluppo di questo MARS Rover sono state coinvolte numerose ditte italiane.
FIAT Spazio è la capocommessa responsabile dell'intero progetto, che vede l'Istituto di Astrofisica dell'Accademia Sovietica delle Scienze, il CNR e l'Università di Perugia responsabili scientifici della missione.
Alla Telerobot del gruppo Ansaldo - Elsag, alla Tecnospazio (un consorzio creato dalla COMAC del gruppo FIAT e della FIAR dell'IRI - Finmeccanica) e alla sovietica LAVOTCHKIN è assegnato lo sviluppo dei sottosistemi.
Un prototipo è stato oggetto di una intensa campagna di prova la scorsa estate nella Valle della Morte in California, dove l'asprezza del territorio e la forte escursione termica notturna e diurna sono ben rappresentative delle difficoltà della missione marziana.
La difficoltà maggiore per il progetto del MARS Rover riguarda la sua autonomia.
Un compromesso opportuno tra carico utile trasportato, autonomia e capacità robotiche consentirà l'ottimizzazione dei risultati per il profilo di missione previsto.
Non è un caso che il gruppo FIAT sia interessato a questo veicolo proprio per la simbiosi bidirezionale che si può instaurare tra discipline di punta, quali l'esplorazione spaziale, e le produzioni industriali di massa, quale quella automobilistica. ■

Dalla Luna a Marte

A sinistra: *un «Veicolo di trasferimento lunare» si distacca dall'astronave-madre per scendere sul nostro satellite. Veicoli di questo tipo serviranno a portare sulla Luna le strutture necessarie per impiantarsi una base stabile, premessa alla realizzazione di una base analoga su Marte. I veicoli non partiranno dal suolo terrestre, ma dall'orbita, avendo come punto di riferimento una base spaziale permanente, successiva alla progettata stazione Freedom che dovrebbe essere montata in orbita nei prossimi anni.*

Qui sopra: *si stanno già progettando i diversi possibili insediamenti lunari. La base raffigurata nel disegno sfrutta come fonte d'energia un grande specchio solare. L'impianto a torre al suo centro serve a estrarre ossigeno dalle rocce lunari.*

zione industriale e nella biologia, ma resta l'interesse per l'approccio innovativo. Invece di mandare veicoli grandi come trattori, e del peso di alcuni quintali che richiedono vettori colossali, miniaturizziamo il tutto e diversifichiamo.
Non più una singola missione omnicomprensiva con satelliti o sonde cariche all'inverosimile di strumenti, con il rischio come spesso è accaduto che una saldatura di poche lire mal realizzata blocchi una intera missione. Invece si tratta di realizzare molte missioni, ognuna leggermente diversa dalle altre, tutte condotte con vettori piccoli, micromacchine, strumentazioni semplici, per lo più a stato solido, figli della rivoluzione informatica.
Se qualcuna si guasta, l'inconveniente non si riflette sulle altre missioni, e complessivamente il programma fornisce comunque risultati. È il concetto della ridondanza applicata non solo alla componentistica ma proprio alla pianificazione delle missioni. E le ripercussioni per le ricadute tecnologiche non sono indifferenti. Un'auto lunare da 200 kg non trova facilmente applicazioni terrestri ma un piccolo robot semovente del peso di pochi chilogrammi, con una telecamera, una sua capacità di elaborazione d'immagine e dati può servire per la manutenzione di impianti nucleari o per il trasporto di sostanze pericolose all'interno di un laboratorio o di un'azienda farmaceutica, mentre il suo sviluppo richiede know-how le cui ricadute terrestri sono innumerevoli.
Naturalmente tutto questo deve essere economico, perché il Rover lunare è stato il veicolo più caro mai costruito dall'uomo. Aereo e treno costano circa 100 lire al chilometro per passeggero, il Saturno 5 sul percorso Terra-Luna costava 5 milioni al chilometro per passeggero, mentre il Rover, costato l'equivalente di 60 miliardi di oggi e utilizzato per un totale di 28 km da due astronauti, ha avuto un costo di esercizio di circa un miliardo a chilometro per passeggero. Alle nuove RAMES, robotica autonoma mobile per l'esplorazione planetaria, si chiede innanzitutto di essere più economiche.

Tecnologie spaziali

MICROROVER SU MARTE

Andranno in avanscoperta sul Pianeta Rosso per preparare l'arrivo dell'uomo. Piccoli robot semoventi dotati di Intelligenza Artificiale studieranno l'ambiente per farci capire come dovranno essere realizzate le prime basi abitabili sulla Luna e su Marte.

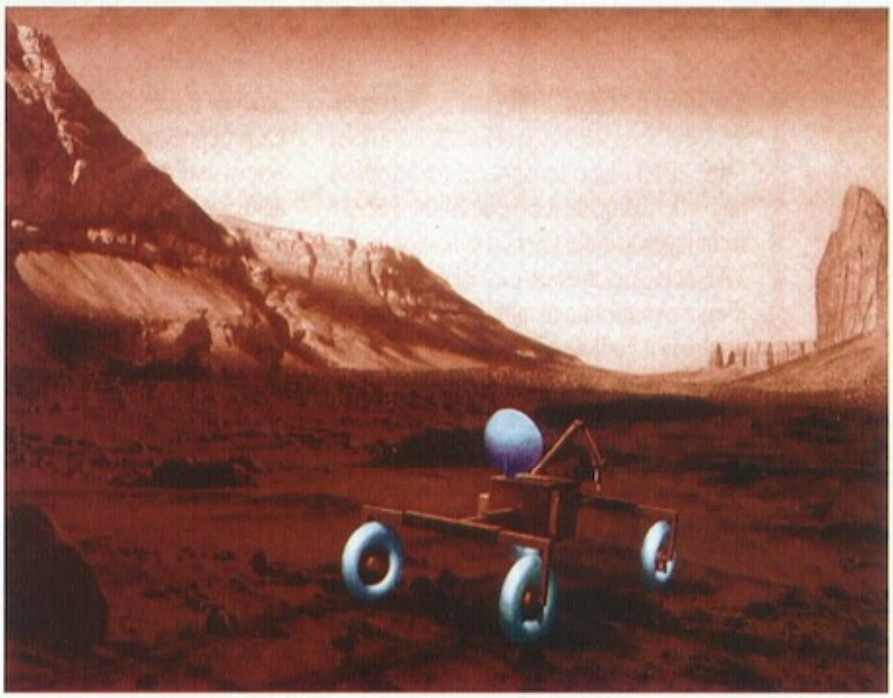
DI CLAUDIO BORGONOVI

All'inizio degli anni 70, gli astronauti del Programma Apollo portarono sulla Luna tre esemplari di vettura lunare, il *Rover*. Costruito dalla Boeing e dalla General Motors, era un'auto elettrica del peso di circa 200 kg, con un'autonomia di 100 km alla velocità di 14 km/h e in grado di trasportare circa 500 kg.
Quattro ruote, ognuna dotata di un motore da un quarto di cavallo e una potenza complessiva pari a un ventesimo di una utilitaria terrestre, questa vettura ha rappresentato per almeno trent'anni l'idea di base per un veicolo automatico in grado di svolgere esplorazioni planetarie.
Se i satelliti per telecomunicazioni, per telerilevamento e per meteorologia rappresentano le attività spaziali più redditizie, l'esplorazione soprattutto di altri pianeti incarna il mito e il fascino dello spazio.
Da parecchi anni sia gli statunitensi che i sovietici stanno progettando una missione umana su Marte e l'esplorazione di altri pianeti e asteroidi. Le difficoltà di bilancio e soprattutto i quasi tre anni di viaggio richiesti da una missione su Marte, rappresentano ostacoli non trascurabili.
I rischi della missione stessa possono essere ridotti tramite una accurata pianificazione, ma ogni volta che si programmano esplorazioni con equipaggio ci si chiede se sia veramente necessario inviare astronauti a milioni di chilometri di distanza solo per prendere qualche campione e qualche foto. A parte le dichiarazioni sul ruolo simbolico dell'astronauta esploratore, indubbiamente solo l'uomo può affrontare rapidamente e con successo situazioni d'emergenza, almeno se queste rientrano nel suo addestramento e non sono troppo gravi.
Ma la presenza dell'uomo a bordo di un'astronave richiede tutta una serie di dispositivi per garantire condizioni simili a quelle terrestri (aria, calore, luce, acqua, pressio-

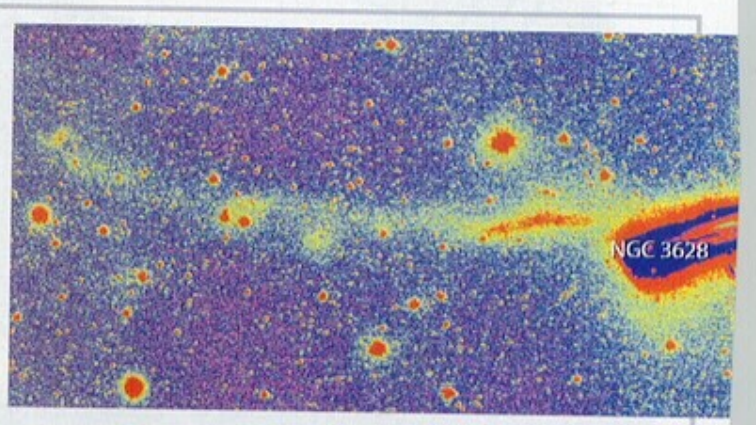
Remoti avamposti

A sinistra: *un «avamposto» sulla superficie marziana, secondo uno dei diversi progetti che attualmente sta valutando la NASA. Potrebbe essere inviato sul Pianeta Rosso entro i primi due decenni del prossimo secolo, per condurre ricerche sul pianeta del Sistema Solare più simile alla nostra Terra.*

A destra: *il suo arrivo sarà preceduto da quello di uno strumento simile a quello qui raffigurato. Si tratta di un VAP (Veicolo Automatico Planetario) che dovrà esplorare palmo a palmo la zona prescelta per l'atterraggio del laboratorio abitato da esseri umani.*



The Leo Triplet's Tidal Tail



A recent study of a well-known galaxy trio shows the value of staring long and hard at even the most familiar targets. M65, M66, and NGC 3628 are three spiral galaxies known to amateur astronomers as the Leo Triplet. They lie 22 million light-years away and are bound up in each other's gravitational grip. Less well known to casual stargazers (because they cannot see it) is a faint, 260,000-light-year-long tail of gas and stars that trails eastward from NGC 3628. Calculations suggest that this tidal tail was drawn out by a close encounter with M66 some 800 million years ago. Visible in deep photographs and at radio wavelengths, the tail has been studied since the 1970s. But much remains to be learned about its properties. In the June *Astronomical Journal,* a Vassar College team led by Frederick R. Chromey describes how it used blue (B-band) and far-red (I-band) CCD images to estimate the ages and masses of four starry clumps in the Leo Triplet tail. The scientists find a wide range of ages, from 12 million to 16 billion years (though the last value is poorly determined since it pertains to the faintest clump). This implies that star formation can occur in gas that has been cast out of its home galaxy by tidal forces. This blue-light image, color-coded to enhance faint features, has north up and is courtesy Frederick R. Chromey.

A Hot Martian Meteorite

German and British scientists have determined that a melon-size meteorite found on May 1st in the Sahara Desert is a piece of Mars. Named Dar al Gani 476, the 15-centimeter-long specimen becomes only the 13th known meteorite with a red-planet pedigree, and it's the first of this kind to be found in a desert environment.

Jutta Zipfel (Max Planck Institute for Chemistry) expressed "no doubt that this was a Martian meteorite" after conducting an initial round of chemical, mineralogical, and noble-gas analyses on a small sample donated by its unidentified owners. British scientists at the Open University confirmed that result by determining the stone's oxygen-isotope ratios, which are considered a reliable test of Martian origin. A sizable impact catapulted the rock into space roughly one million years ago, and it probably lay in central Libya 20,000 to 40,000 years before being found. Zipfel says the composition is basaltic and most similar to the type called shergottites. According to Colin T. Pillinger (Open University), the meteorite "seems to be from a different formation and possibly a different age than the others," making this find especially exciting.

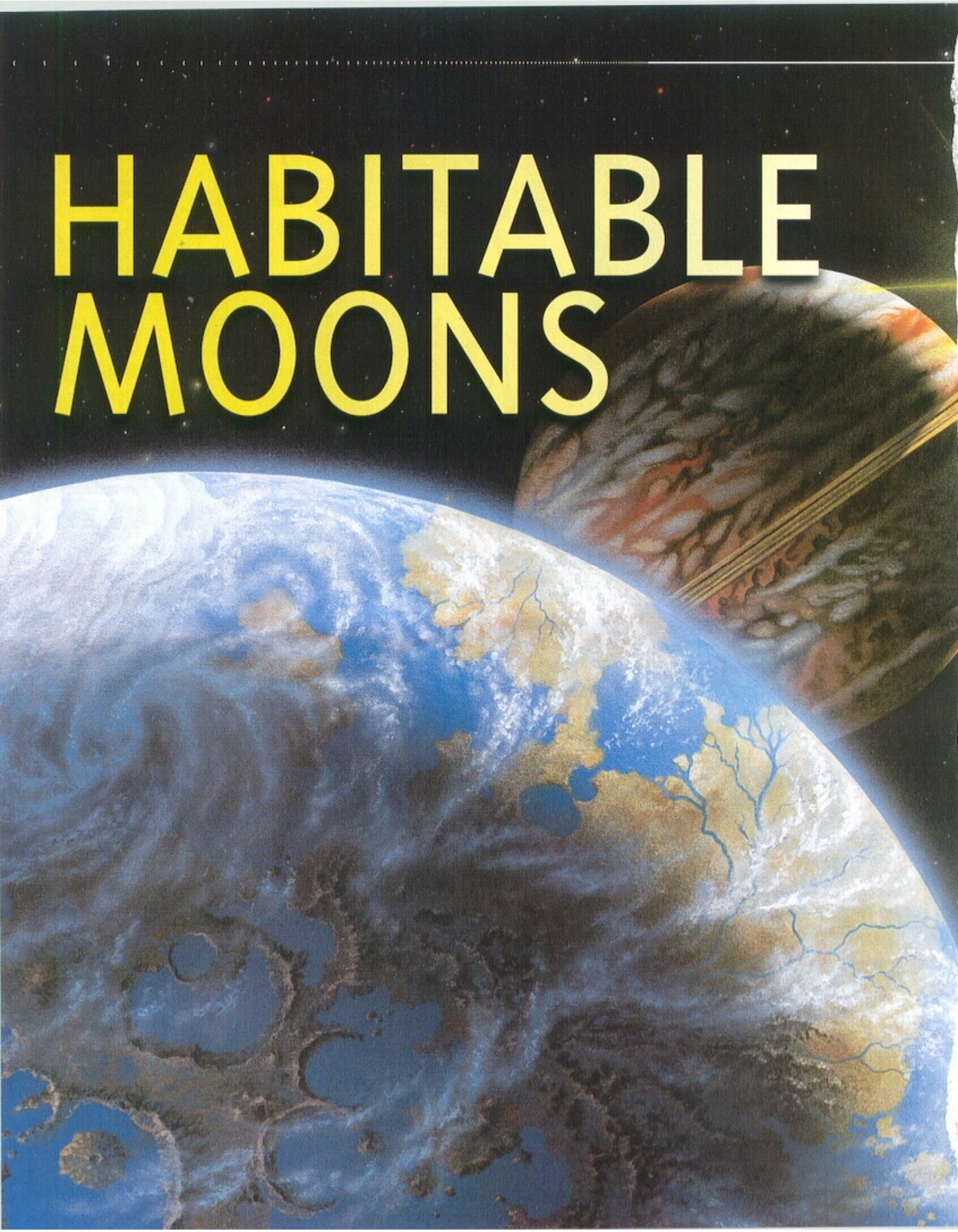
Because of the notoriety gained in 1996 by another "Martian," ALH 84001, researchers plan to scrutinize Dar al Gani 476 for fossilized life forms. However, Zipfel warns, "The search for past evidence of life in this meteorite will be severely impeded because it was lying in the hot desert and not in a relatively sterile environment such as Antarctica." The stone is heavily weathered with carbonate minerals lining interior fractures and rimming individual grains. Even so, planetary scientists hope its compositional uniqueness will improve our knowledge of the geochemistry and evolution of Mars.

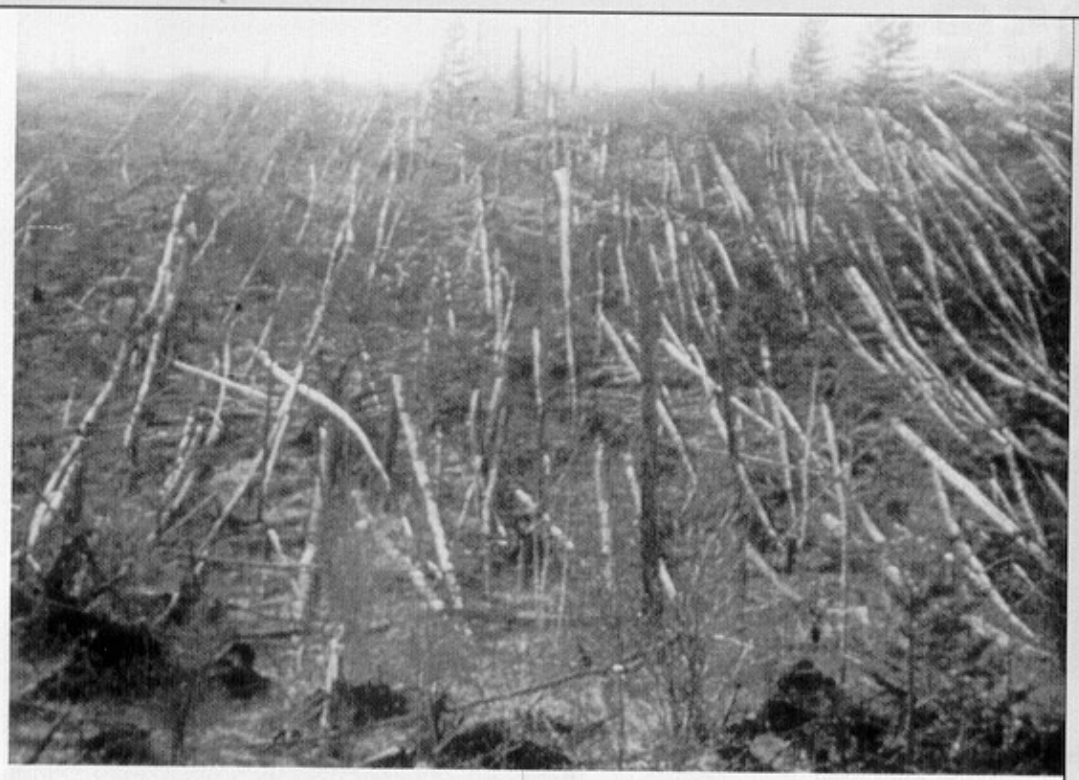
Meanwhile, a good-size *lunar* meteorite was found on March 10th in the same region of the Sahara Desert. Named Dar al Gani 400, the stone is a fine-grained fusion of rock fragments with a mass of 1.425 kilograms. It becomes the 14th known lunar meteorite (four others are paired pieces). Dar al Gani 400 is the largest of all of these and one of only three in private hands.

Above: Dar al Gani 476 is the first Martian meteorite discovered since 1994. Weighing in at 2.015 kilograms, the loaf-shaped stone is worth about $1,000 per gram on the commercial market. Courtesy Jutta Zipfel (Max Planck Institute for Chemistry).

A Controversial Quasar Timed Anew

A narrowly separated pair of 17th-magnitude spots in Ursa Major, designated 0957+561, is the gravitationally doubled image of a distant quasar. An intervening galaxy deflects both visible light and radio waves that emanate from the quasar; these forms of electromagnetic radiation reach Earth along two sightlines that differ slightly in length. Just *how* slightly has been a matter of contentious debate, as it indirectly affects estimates of the universe's expansion rate. The latest chapter in the twin quasar's saga will be published in the *Astrophysical Journal,* where Deborah B. Haarsma (Haverford College) and her colleagues will describe a decade's worth of radio data on 0957+561. By timing brightness fluctuations in each quasar image, Haarsma's team has determined that our sightlines to the quasar differ in length by 400 days (plus or minus 10 percent). This bolsters the case of Rudolph E. Schild, who has long held out for a 400-day delay despite counterclaims by his Harvard-Smithsonian Center for Astrophysics associate William H. Press.


HABITABLE
MOONS



Trees near the Tunguska River in Siberia still echoed devastation nearly two decades after a large meteorite exploded 5 miles above the ground in June 1908. The Tunguska event, which ranks as one of the most violent cosmic impacts of this century, leveled nearly 1,400 square miles of taiga forest. Courtesy Sovfoto.

artillery shells followed by great balls of fire that fell from the sky like thunderbolts. Three massive explosions and three shock waves ripped through the jungle, followed by a very light rain of ash that veiled the Sun until midday. The blasts were heard up to 150 miles away, while the resulting magnitude 7 earthquake was recorded 1,300 miles away in La Paz, Bolivia. This massive meteor explosion would not have been known to the outside world if not for a Capuchin monk, Father Fedele d'Alviano, who had visited the terrified population during his yearly apostolic mission and then written about the event for the papal newspaper.

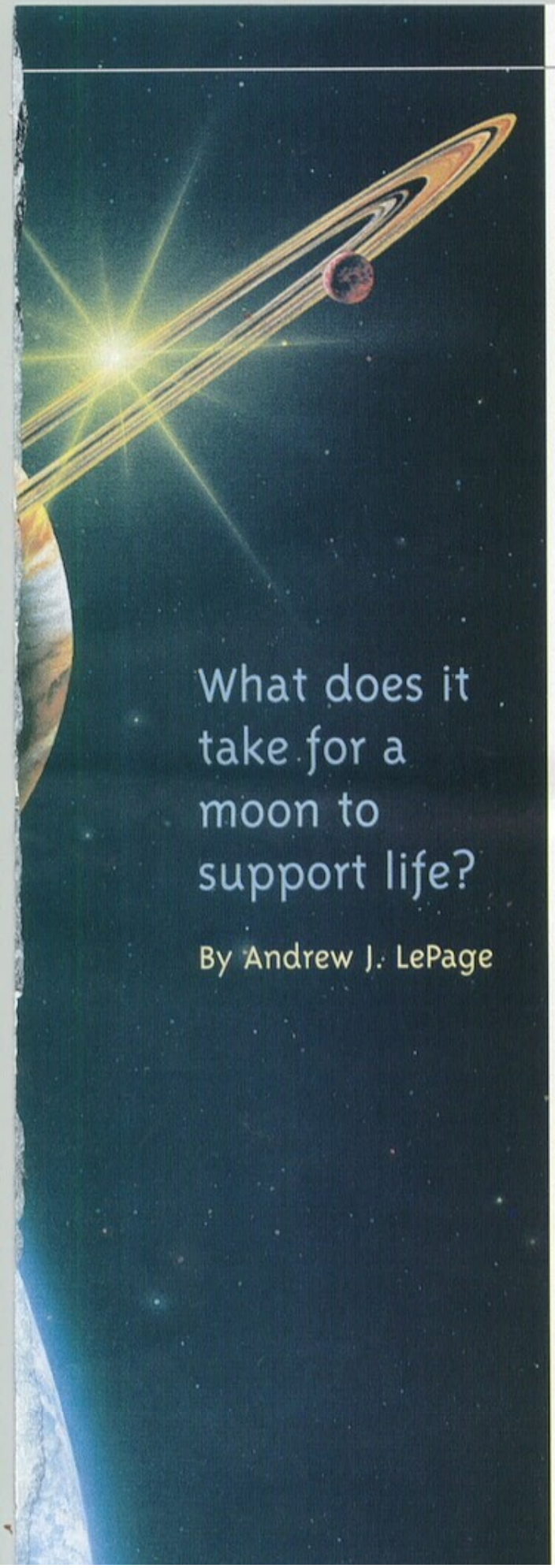
The collision of Comet Shoemaker-Levy 9 with Jupiter in July 1994 was a widely publicized event. Most of the educated population in the world heard about the dark impact scars on the Jovian atmosphere, each larger than Earth. If such a comet were to hit Earth, mass extinction would be the most likely scenario. The moral of the Amazonian Tunguska and Shoemaker-Levy 9 events is that such occurrences are not unique even in modern times. Collisions of catastrophic proportions and worldwide scale can happen anytime within our lifetimes.

Over the last decade or so, there has been a big change of consciousness among both scientists and the general public. The paradigm now is the realization that the Earth is a target in a giant shooting gallery, with the stakes as large as civilization itself. Countless articles, books, and movies on the threat of meteorite impacts have already appeared (see the June issue, page 26). Thankfully, the larger the explosion, the rarer the event. Metropolis destroyers, with an explosive energy on the order of 100 million tons of TNT, happen roughly once per millennium. Regional destroyers, about 100 billion tons of TNT, have an event rate of around once per hundred millenniums. Civilization destroyers, about 100 trillion tons of TNT, average once every 10 million years or so.

So how can we defend ourselves? Most ideas center on finding any objects on a collision course and shifting their orbits perhaps using nuclear warheads. Any such solutions must have tradeoffs between the degree of advance notice and the size of the diversion. A tradeoff for society is to decide how many resources should be put into the meteorite threat instead of into more immediate possible catastrophes, such as overpopulation, environmental collapse, or nuclear war.

Astronomical events have changed history and affected the lives of ordinary people in a surprising number of ways, but only meteorites actually come down to Earth. They have had a great impact on humanity — as a resource for building civilization, as a god come to ground, and as the cause of mass die-offs. But as you are watching the fiery trails of Leonid bolides, please remember only the majesty and not the terror.

Bradley E. Schaefer *suffers constant agonies from having slept through the 1966 Leonid meteor storm when he was nine years old in Denver, Colorado.*



What does it take for a moon to support life?

By Andrew J. LePage

One of astronomy's most exciting discoveries in recent years has been the detection of worlds orbiting stars other than our own. More interesting still is that some of these extrasolar giant planets (EGPs) orbit within the "habitable zones" of their suns — that is, within the range of orbital distances where liquid water should exist and, in theory, life could survive. According to conventional wisdom, however, it is highly unlikely that life, much less intelligent life, could arise on these giant, gaseous planets. But what about their moons? Could they support habitable, Earth-like conditions where a technological civilization might evolve?

In our own solar system, the larger the gas giant the greater the total mass of its satellites. So perhaps EGPs larger than Jupiter have moons larger than Mars. Brown dwarfs, which are even more massive and have also been found closely orbiting a few nearby Sun-like stars, might have moons larger than Earth itself. Worlds this big could be quite livable. (Since brown dwarfs are failed stars, their companions should probably be labeled planets. However, the classification of some of the recently discovered extrasolar companions is still controversial, so for convenience I will refer to the companions of both EGPs and brown dwarfs as moons.)

One factor determining a moon's habitability is the stability of its orbit, which can be disrupted by the close proximity of its sun. Studies of multibody systems suggest that a moon with a period of revolution of less than about 45 to 60 days will remain bound to an EGP or brown dwarf that orbits 1 astronomical unit from a Sun-like star. The major moons of our solar system's gas giants all have orbital periods between 1.7 and 16 days regardless of the mass of the planet. This suggests that the total angular momentum of a gas planet's system of moons is also roughly proportional to the planet's mass. If a similar scaling law applies to the moons of EGPs and brown dwarfs, a 16-day orbit is still significantly shorter than the upper limit for stability. At the other end of the range a 1.7-day orbit puts the moon well outside the Roche limit, where a moon would be sheared apart by tidal forces. Assuming there are no impediments to moon formation, EGPs and brown dwarfs in a star's habitable zone can thus have large moons in very stable orbits.

An Earth-like world orbiting a gas giant planet. Until recently this scene would have been pure science fiction, but the discovery of substellar companions to nearby Sun-like stars suggests that such worlds are likely to exist. If they do, some could be sites for life.

ILLUSTRATION BY LYNETTE COOK

JPL/NASA

Although no habitable moons exist in our solar system, the Galileo mission to Jupiter is giving us insights into such worlds. Among Galileo's findings is a magnetic field for Jupiter's moon Ganymede, produced by an active dynamo inside the moon's core. A magnetic field is needed to shield a habitable moon's atmosphere from erosion caused by the magnetosphere of a giant planet or brown dwarf.

Keeping an Atmosphere

For a moon to be ideally habitable, it would have an appreciable atmosphere. Obviously such a body must be larger than Earth's own airless Moon, which has a mass 0.012 times that of Earth, but how much larger? Darren Williams, James Kasting, and Richard Wade (Pennsylvania State University) have examined this problem in detail and found that a number of processes allow a world's atmosphere to escape.

The first is well known. Some gas atoms in the upper atmosphere attain speeds faster than the escape velocity as a result of thermally driven collisions and are soon lost. For the atmosphere to be retained for long periods, this process must be kept very slow. Either the temperature at the top of the atmosphere must be low, or the world must be massive enough to have a high escape velocity. For a body with a Mars-like density and an Earth-like atmospheric temperature structure, calculations show that it must have a mass of at least 0.07 Earth to retain most of its atmosphere for 4.6 billion years (the current age of the Earth).

The escape of some atmosphere is not necessarily fatal. On Earth carbon dioxide can be replenished from the vast stores of this gas locked up in carbonate deposits. However, the loss of some other biologically important gases, like nitrogen, is irreversible. A major loss mechanism for nitrogen is called *dissociative recombination*. This process starts when a positively charged nitrogen molecule at the top of the atmosphere combines with an electron to produce a pair of free nitrogen atoms. The energy released by this reaction gives the now neutral atoms enough of a kick to permanently escape. Estimates based on Mars's nitrogen-loss rate indicate that dissociative recombination becomes negligible for a world with a minimum mass of 0.12 Earth at a distance of 1 a.u. from a Sun-like star.

A potentially greater threat to a moon's atmosphere is sputtering. This process occurs when an energetic charged particle collides with a gas molecule and the rebound kicks the molecule into space. The magnetospheres of the gas giants in our solar system, and presumably of EGPs and brown dwarfs as well, contain radiation belts potent enough to completely erode the atmosphere of an orbiting Earth-like world in only a few hundred million years.

One way to blunt this form of atmospheric loss is

JPL/NASA

Images returned by the Galileo spacecraft indicate that Jupiter's moon Europa has a tidally heated ocean below its icy crust, possibly capable of harboring life. However, Europa is not considered a "habitable" body where a technological civilization might someday evolve.

STAR OBSERVER

GRATIS-KALENDER
Mondphasen und Planetenlauf 1998

Nr. 6/97
DEZEMBER

STAR OBSERVER

Magazin für Astronomie und Weltraumforschung

Y 922
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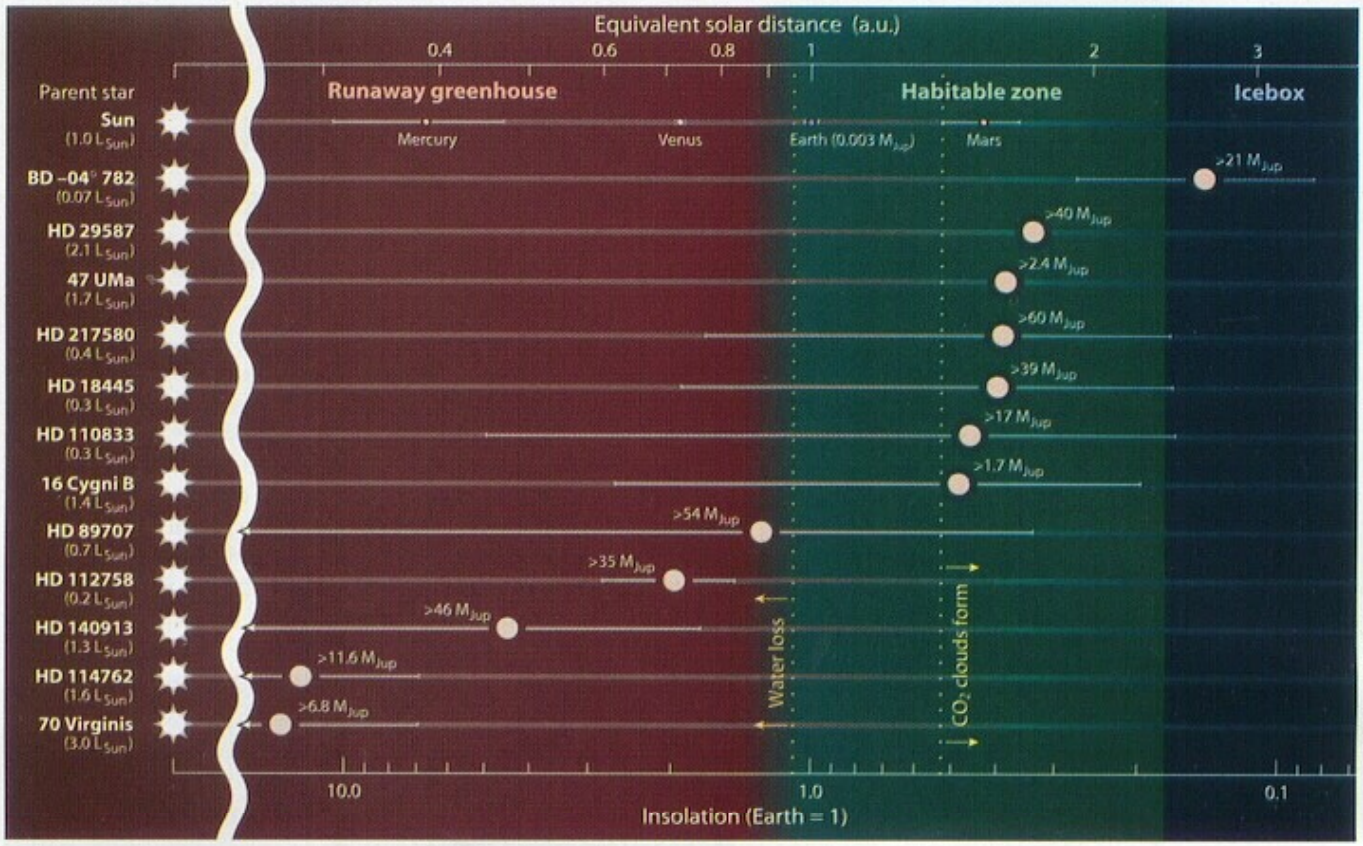


The orbits of some recently discovered extrasolar planets and brown dwarfs, shown in relation to their stars' habitable zones. Each horizontal line shows the distance of a body from its star (which can range greatly due to an eccentric orbit), with a large dot marking the mean distance. The orbits of our solar system's terrestrial planets are shown for comparison. Those bodies that do not stray too far into the red zone *(Runaway greenhouse)* or blue zone *(Icebox)* are prime candidates for harboring habitable moons.

as its orbit evolved through distorting resonances with its siblings over the past few billion years. The magnitude of tidal heating depends on a number of factors such as the mass of the moon and its primary, the moon's internal structure, the size and eccentricity of its orbit, and the orbits of its near neighbors. Large moons around EGPs probably experience some

ZONES of HABITABILITY

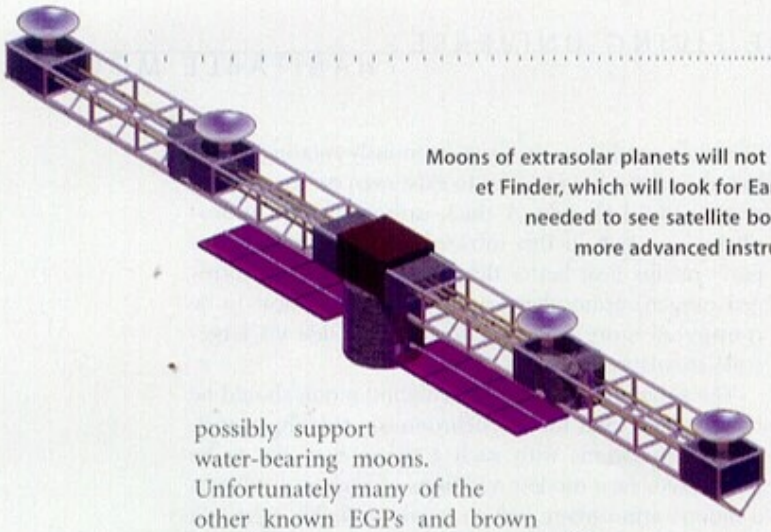
A star's "habitable zone" is the region where a habitable, Earth-like planet or moon can exist. Such a world is usually defined to be one that has surface temperatures allowing for the existence of liquid water over a substantial portion of its surface. While Mars or the Jovian moon Europa might have biocompatible environments where life may exist, they are not promising sites for the development of advanced forms of life and are not generally considered to be habitable.

The size and location of a star's habitable zone depend on the amount of solar energy, or insolation, a world receives. A further constraint is the amount of greenhouse gases, such as carbon dioxide, in its atmosphere.

In the past decade planetary climate researchers have come to realize that the amount of carbon dioxide in the atmosphere of a geologically active world like our own is primarily controlled by the carbonate-silicate cycle. On a terrestrial body this process starts when rain containing dissolved carbon dioxide weathers silicate minerals. The products of these reactions are carried to the ocean, where they eventually precipitate to form climatically inert carbonate deposits. On a geologically active world these deposits will eventually reach the mantle by the subduction of crustal plates (as happens on Earth) or by some other tectonic process. Once in the mantle, the carbonate deposits are heated and transformed back into carbon dioxide that can be released into the atmosphere through volcanism.

Because of the way this cycle works, excess carbon dioxide is removed from the atmosphere when it is too hot because of enhanced amounts of precipitation and rates of weathering. When it becomes too cold, precipitation and weathering slows, thus allowing volcanically derived carbon dioxide to build up in the atmosphere. In effect, the carbonate-silicate cycle is a slow-acting, global thermostat.

James Kasting (Pennsylvania State University) and his colleagues have per-



Moons of extrasolar planets will not be spotted any time soon. Even NASA's proposed Terrestrial Planet Finder, which will look for Earth-like planets orbiting nearby stars, will not have the resolution needed to see satellite bodies. Their detection will have to await subtler techniques or still more advanced instruments later in the next century. Courtesy NASA.

possibly support water-bearing moons. Unfortunately many of the other known EGPs and brown dwarfs have eccentric orbits that would complicate habitability due to large swings in the amount of sunlight reaching them. The mean insolation of the EGP orbiting 16 Cygni B, for example, is about half that of Earth, but this level ranges from 20 percent to as much as 260 percent of the sunlight on Earth because of the planet's eccentric orbit.

As in the case of planets with long days, the presence of a dense carbon-dioxide atmosphere could lessen these extremes. Since the companion to 16 Cygni B lies on average in the outer portion of its system's habitable zone, any large moon it possesses could have the required dense atmosphere as a result of the carbonate-silicate cycle. Other candidates in this category include the brown dwarfs orbiting HD 110833, BD –04 782, HD 18445, and HD 217580.

The Future

The detection of moons suitable for life will probably be more difficult than the detection of habitable terrestrial planets. None of the telescopic systems that have been proposed to detect Earth-size planets around nearby stars will have the resolution required to separate the image of a moon from its primary. Photometric searches for planetary transits, such as the proposed Kepler mission, might have better luck. But the ever-changing position of these moons in relation to their primaries will require the observation of many transits to isolate a moon's photometric signature. Given the difficulties, the unambiguous detection of an extrasolar moon, habitable or otherwise, is probably decades away.

Much theoretical work remains to be done to determine the possible abundance of these bodies. A detailed understanding of the origins of brown dwarfs and EGPs is required, not to mention the origin of moon systems themselves. The distribution of volatiles like water in a moon system, and how this is affected by the thermal history of the primary, will also have to be better understood.

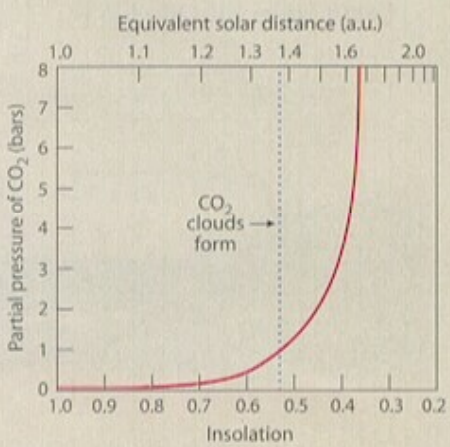
Still, there may be millions if not hundreds of millions of habitable moons in our galaxy. Given that large moons generally occur in groups among the gas giants in our solar system, habitable moons could also occur in groups of two or more per planet. It's anyone's guess what the implications may be for the abundance of life and the possible development of extraterrestrial intelligence.

ANDREW J. LEPAGE *is a physicist and writer specializing in astronomy and the history of spaceflight.*

planet retains its water despite this mechanism, a runaway greenhouse effect that would sterilize the planet finally sets in closer than 0.84 a.u.

As we move out from the inner edge of the habitable zone, the carbonate-silicate cycle slowly increases the amount of atmospheric carbon dioxide to maintain above-freezing temperatures. While these high levels of carbon dioxide would be fatal to humans, native life forms that evolved in such an environment would thrive.

According to Kasting's work, when an Earth-like planet is 1.37 a.u. from the Sun, the top of its carbon-dioxide-rich atmosphere starts to freeze and form carbon-dioxide ice clouds. If the clouds are thick and their particles are small, they will reflect light efficiently and cool the planet. If this is true, then 1.37 a.u. is the outer limit of our Sun's current habitable zone.



The amount of carbon dioxide required to keep oceans liquid. The carbon-dioxide content of the atmosphere increases with decreasing insolation (on Earth, insolation is 1.0) as a result of the carbonate-silicate cycle. If there are no clouds the maximum greenhouse limit is reached at an equivalent solar distance of 1.67 a.u. Courtesy Andrew LePage.

However, recent studies by François Forget (Laboratoire de Météorologie Dynamique, Paris) and Raymond Pierrehumbert (University of Chicago) indicate that these clouds could contain much larger particles, which are excellent reflectors of infrared radiation. Such clouds would actually help a world retain heat like a blanket and augment the greenhouse effect. The outer limit of the habitable zone could then extend out to 2.4 a.u., where the required amount of atmospheric carbon dioxide reaches 5 to 10 bars. At this point the atmosphere is so thick that the addition of more carbon dioxide will not increase surface temperatures. Beyond this limit a world's oceans freeze and it becomes a giant ice cube.

amount of tidal heating that could help maintain habitable conditions far longer than even much larger terrestrial planets could in isolation.

Length of Day

Another potential problem for habitable moons is the length of their day. Computer models show that any large moon orbiting an EGP or brown dwarf becomes locked into synchronous rotation (with one side of the moon always facing the planet) within a few hundred million years. This, of course, has happened with our own Moon and many other large moons in the solar system. Assuming that large moons typically have orbital periods of 1.7 to 16 days, any potentially habitable moon would have a "day" several times longer than Earth's. Simple calculations by Stephen Dole of the Rand Corporation in the 1960s showed that the surface of a body with an Earth-like atmosphere would become uninhabitable when the period of rotation exceeds 4 days, due to large swings in surface temperature.

In reality the situation for slowly rotating moons would probably be not so bleak. Monoj Joshi and Robert Haberle (NASA/Ames Research Center) and their colleagues have been investigating the effects of synchronous rotation on the habitability of planets closely orbiting red-dwarf stars. Such a planet would become tidally locked so that one hemisphere always faces its sun while the other experiences perpetual night.

Joshi and Haberle's latest computer models have shown that an atmosphere with a carbon-dioxide pressure of only 1 to 1.5 bars (a bar is the atmospheric pressure on Earth) not only maintains habitable conditions on a synchronously rotating planet but also allows liquid water to exist even on the planet's perpetually dark side. A thick carbon-dioxide atmosphere (one rich in this infrared-trapping "greenhouse gas") retains heat better than a thin Earth-like (nitrogen-oxygen) atmosphere, and it allows this heat to be transferred more efficiently to the dark side via large-scale circulation patterns.

The situation with a slowly rotating moon should be less extreme than for a synchronously rotating planet. While simulations with such a moon have yet to be performed, even modest additions of carbon dioxide to a moon's atmosphere (which would probably exist as a natural consequence of the carbonate-silicate cycle) will likely allow it to remain clement despite having a day as long as two weeks. Clouds and large bodies of water, which have not been taken into account in models to date, should further moderate temperature extremes.

Problems of Eccentricity

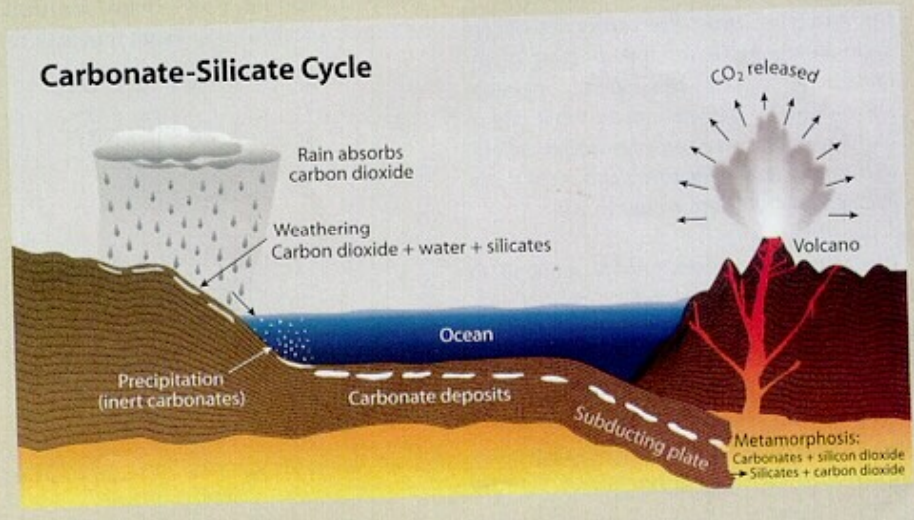
A number of recently discovered EGPs and brown dwarfs have mean orbital distances that lie inside the habitable zones of their suns. The companions of the Sun-like stars 47 Ursae Majoris and HD 29587 in Perseus, while near the outer limits of their systems' habitable zones, could

None of the telescopic systems that have been proposed to detect **Earth-size planets** around nearby stars will have the resolution required to separate the **image of a moon** from its primary.

formed calculations that incorporate the climate-stabilizing effects of the carbonate-silicate cycle. Their results suggest that the inner edge of a star's habitable zone lies where the carbonate-silicate cycle has already removed most of the carbon dioxide from a world's atmosphere. Closer to a star, the temperature starts to rise out of control with increasing insolation. Because of increased evaporation, water vapor builds up in the atmosphere to produce a moist greenhouse effect. Eventually the heat allows water vapor to rise high in the upper atmosphere, where it is broken down by the star's ultraviolet light and the world's hydrogen atoms are permanently lost.

This water-loss limit, which in our solar system occurs 0.95 astronomical unit from the Sun, is the first inner boundary of the habitable zone. Assuming that a

Because of the temperature-sensitive nature of weathering and rainfall, this cycle tends to maintain a carbon-dioxide greenhouse effect just great enough to allow liquid water to exist on a planet's surface. Only in the past decade has this cycle's importance in stabilizing Earth's long-term climate been appreciated.



through the shielding effects of a strong magnetic field. Measurements by NASA's Galileo spacecraft at Jupiter hint that large moons might have magnetospheres of their own with the required strength. Galileo has unambiguously detected a strong Earth-like magnetic field around Ganymede, which has a mass of only 0.025 Earth. The situation with Io, with a mass of 0.015 Earth, is a bit more ambiguous but still promising.

The magnetospheres of the gas giants in our solar system . . . contain **radiation belts** potent enough to completely **erode the atmosphere** of an orbiting Earth-like world in only a few hundred million years.

Researchers once believed that small bodies like Jupiter's Galilean moons could not possess such strong fields. But these moons orbit deep inside Jupiter's own powerful magnetosphere. According to models developed by Graeme Sarson (University of Exeter) and his colleagues, a strong ambient field is thought to help initiate the circulation needed to produce a vigorous dynamo effect in the core of even a slightly active moon, leading to a strong field for the moon itself. Taken together, these observations and models hint that planet-size moons can maintain protective magnetic fields that they would not have in isolation.

Maintaining Geologic Activity

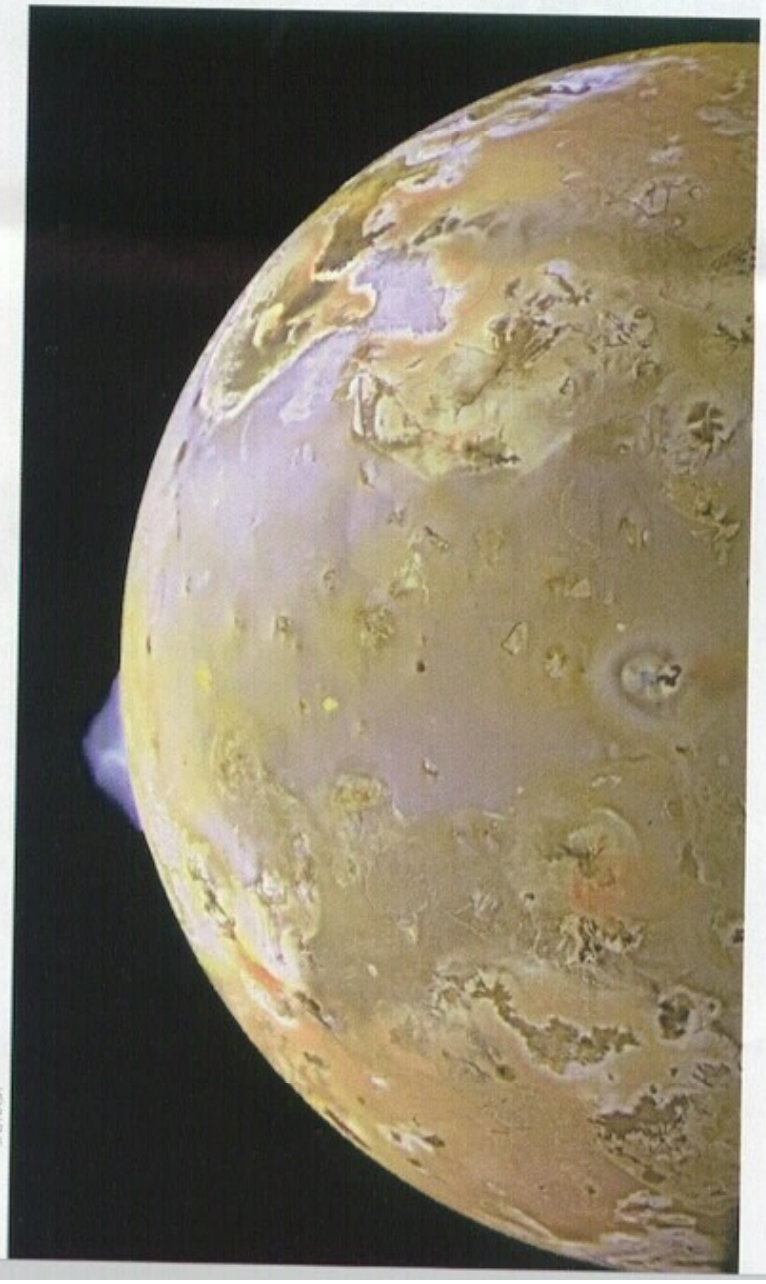
For a moon to have an active dynamo producing a magnetic field it must have a source of internal heat. But even more internal heat is required to drive another process that may be necessary: the geologic activity needed for the carbonate-silicate cycle, which controls global atmospheric temperatures (see the box on page 54). Without this important cycle to maintain atmospheric carbon-dioxide levels, an otherwise habitable world will experience a perpetual ice age much as Mars does today.

The most important current source of internal heat for our solar system's terrestrial planets comes from the decay of radioactive isotopes. This heat production decreases with time, however, and small bodies cool faster than large ones. As a result, large planets like Earth can support the carbonate-silicate cycle longer than small planets like Mars. While the amount of internal heat needed is still a subject of debate, it is estimated that a world's mass must be at least a quarter that of Earth to maintain this cycle for 4.6 billion years if radiogenic sources are the only heat producers.

But large moons orbiting an EGP or brown dwarf have an additional source of energy that our terrestrial planets lack: tidal heating. A spectacular example of this phenomenon is Jupiter's moon Io. The constant flexing of Io's surface as the moon circles Jupiter in its slightly eccentric (elliptical) orbit generates enough heat to make it the most volcanically active body in the solar system.

Europa may be experiencing a lesser degree of tidal heating, which is still enough to maintain the ocean of liquid water that apparently exists beneath its icy shell.

Ganymede has a magnetic field and evidence of past geologic activity that both suggest this largest moon of Jupiter experienced episodes of enhanced tidal heating



Small planets and moons usually cool quickly and become geologically inactive. To maintain habitable surface conditions, a body must be active enough to drive the carbonate-silicate cycle that controls the amount of greenhouse gases in its atmosphere. Io, shown here, is the most volcanically active body in our solar system, despite its Moon-like size, because of tidal heating. Such a heat source could help a small moon maintain a good climate for a very long period.

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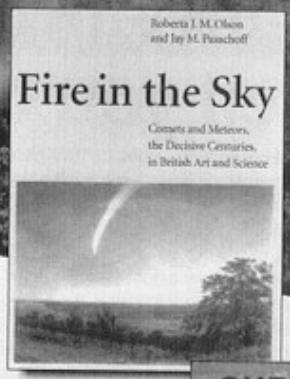

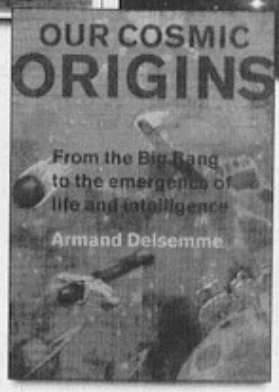

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This textbook provides a systematic review of the observed properties of AGN across the entire electromagnetic spectrum, examines the underlying physics, and shows how the brightest AGN—quasars—can be used to probe the farthest reaches of the Universe.

1997 251 pp.
0-521-47911-8 Paperback $27.95

Deep-Sky Companions: The Messier Objects

A New Look at the Most Famous Deep-Sky Wonders in the Heavens

Stephen James O'Meara

"All the essentials are here...O'Meara's book will be an invaluable guide to some of the finest showpieces in the heavens."
– New Scientist

1998 c.240 pp.
0-521-55332-6 Hardback $34.95

Galaxy Morphology and Classification

Sidney van den Bergh

This long-awaited book by one of the pioneers of the field provides a concise and up-to-date summary of current ideas about galaxy morphology and classification. This is the first book dedicated entirely to the shape and classification of galaxies. It introduces the most widely used schemes, explains how they have developed and what they can tell us about galaxies.

1998 124 pp.
0-521-62335-9 Hardback $39.95

Our Cosmic Origins

From the Big Bang to the Emergence of Life and Intelligence

Armand H. Delsemme

Our Cosmic Origins tells the story of our remarkable adventure on this planet, beginning with a single event in the depths of space. It traces the rich and wonderful history of the Universe, from the Big Bang to the creation of atoms and molecules, from the formation of stars and planets to the emergence of life on Earth.

1998 320 pp.
0-521-62038-4 Hardback $24.95

The Search for Life on Other Planets

Bruce Jakosky

Using the early history of the Earth and the conditions that would allow life to exist, Jakosky creates a sound, scientific foundation for the possibility of life on planets other than our own.

1998 336 pp.
0-521-59165-1 Hardback $59.95
0-521-59837-0 Paperback $19.95

The Heavens on Fire

The Great Leonid Meteor Storms

Mark Littmann

Littmann traces the history and mythology of meteors, profiles the fascinating figures whose discoveries advanced the field, and explores how meteors have changed the course of life on Earth. He offers advice on how and where to make the best of the 1998, 1999 and 2000 return of the Leonids.

1998 c.288 pp.
0-521-62405-3 Hardback $39.95

Sky Atlas 2000.0

Second Edition

Wil Tirion

The atlas opens out to reveal 26 charts, each one 20 inches wide and 15 inches deep. This large format allows the stars, nebulas and galaxies to be displayed with unrivaled clarity. For this edition, improved isophotal (objects with same light intensity) maps are used for the Milky Way, and extra charts for crowded areas of the sky have been added.

1998 c.30 pp.
0-521-62762-1 Paperback $49.95

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MISSION UPDATE

BY JONATHAN McDOWELL

Launch Failures

The space industry was recently hit with a streak of four launch failures during a month-long interval. The dismal roll call began on August 12th with a spectacular, billion-dollar fireworks display over Cape Canaveral. A Lockheed Martin Titan IV-A suffered a momentary power failure 40 seconds after liftoff, causing its guidance computer to reset itself and command the huge rocket to tip over. The vehicle disintegrated, and a large military-intelligence satellite was lost. Next came the debut of Boeing's Delta III rocket on August 26th. It also fell victim to a guidance failure, this time caused by poor modeling of the rocket's dynamic response. The control system was unable to damp out an oscillation and ran out of fuel, dumping a communications satellite into the Atlantic Ocean. At the end of August North Korea claimed to have launched its first satellite. The United States could not find the payload in orbit, however. It now seems likely that the satellite, which reportedly was broadcasting the revolutionary songs of Kim Il Sung, came to rest on the Pacific seabed. During the fourth failure, on September 9th, a payload of 12 telephone-relay satellites was propelled at high speed into the Siberian tundra when a Zenit rocket launched from Kazakhstan shut down too early. Although none of these four vehicles are slated to carry future astronomical satellites, the indirect effects of finding new launch slots for high-priority commercial payloads may cause some delay for pending science missions.

CRAIG RUBADOUX / FLORIDA TODAY (2)

The ill-fated flight of a Titan IV-A rocket and its classified payload on August 12th lasted just 40 seconds.

Mars Surveyor 1998

NASA's Mars Climate Orbiter (MCO) arrived at Cape Canaveral on September 11th in preparation for its launch on December 10th. A three-stage Delta II rocket, fortified with four strap-on, solid-fuel boosters, will place the 3,100-kilogram spacecraft into orbit around the Sun. After that, the first critical maneuver for MCO will be to deploy its solar panels — its precursor, Mars Global Surveyor, had problems with this task. Then on December 25th MCO's main engine will redirect the trajectory toward Mars (the initial path will be a deliberate "miss" so that the Delta rocket stage can't contaminate the Martian surface). The launch of MCO's companion, Mars Polar Lander (MPL), will follow on January 4th with a similar sequence of events. MCO is to reach the red planet in September 1999, with MPL arriving three months later.

NASA / JPL

The Mars Climate Orbiter will study the red planet's surface and atmosphere with a high-resolution color camera and an infrared radiometer.

Advanced X-ray Astrophysics Facility

Soon to be renamed by NASA, the forthcoming AXAF satellite completed its main prelaunch tests in August and was shipped to Florida from TRW's California factory in late September. During vacuum testing earlier this year, a door on the CCD Imaging Spectrometer camera failed to open. Engineers made some quick hardware modifications and improved operating procedures, and the door passed a retest with flying colors and preserved a January 21st launch date aboard the Space Shuttle *Columbia*. Meanwhile, the five-member crew continued to train for the mission (October issue, page 28). After this shuttle orbiter flew in May, its Spacelab module and long-duration equipment were removed to make room for the X-ray telescope. In October NASA begins stacking the shuttle's Solid Rocket Boosters in the huge Vehicle Assembly Building, and on December 4th *Columbia* will be hoisted up and bolted to the boosters and external tank, before being rolled out to the launch pad a week later. AXAF will be connected to its Inertial Upper Stage booster and then loaded into *Columbia* on the launch pad.

Solar and Heliospheric Observatory

The slow recovery of the SOHO satellite continued early this fall. Having reestablished contact with the spacecraft after a month's silence (October issue, page 28), on August 13th ground controllers began a slow, careful thawing of the craft's frozen hydrazine fuel. They then warmed the rest of the propulsion system. The thrusters returned to life on September 16th, pointing the craft back at the Sun and allowing the instruments to warm up. The next step will be to begin turning on the scientific instruments, whose electronic health remains unknown. The spacecraft's uncontrolled tumble alternately heated and cooled the science module, and some detectors may have been damaged.

JONATHAN McDOWELL, *an astronomer at the Harvard-Smithsonian Center for Astrophysics, writes a weekly electronic newsletter on the space program (http://hea-www.harvard.edu/QEDT/jcm/space/jsr/jsr.html).*

guate, si possono ottenere laser di circa 47 nanometri di lunghezza d'onda.

Ci sarebbero anche i «buchi grigi»

Dopo i buchi neri, i «buchi grigi». L'espressione è stata coniata dall'astronomo americano Kenneth Brecher dell'università di Boston, per indicare gli astri posti a uno stadio intermedio tra le cosiddette «stelle a neutroni» (molto luminose) e i buchi neri, difficilmente osservabili. Per Brecher, quando una stella in fin di vita agonizza, se la sua massa è compresa tra le due-tre volte quella del Sole, è possibile che si trasformi in un buco grigio, circondato da una sfera di fotoni che non possono «scappare»: la luce della stella, contratta dalla gravitazione, entrerebbe cioé, obbligatoriamente, in una sorta di orbita attorno alla stella, mentre solo il 2% dei raggi luminosi riuscirebbero a disperdersi nello spazio. (M.L.)

15-1-95

INDIPENDENTE 6.6.95

Urss, 200 morti nello spazio

MOSCA. Il sogno dell'uomo di conquistare lo spazio è costellato di tragedie. Chi non ricorda la terribile esplosione che nel 1986 distrusse lo Shuttle appena decollato dalla base americana di Cape Canaveral uccidendo 7 astronauti? Episodi simili, ancora più drammatici, si verificarono anche nell'ex Urss, ma furono tenuti rigorosamente segreti e soltanto ieri sono stati rivelati dalla tv russa (nella foto Olympia, una missione Soyutz). Il primo, nel '60, costò la vita a 56 persone, e fu archiviato con il nome di "Disastro Nedelin"; otto anni più tardi, nel cosmodromo di Baikonur esplose un razzo gigante: ben 91 i morti.. In tempi più recenti, 51 ingegneri furono dilaniati dallo scoppio di un altro razzo saltato in aria quando ancora era fermo sulla rampa di lancio del cosmodromo di Pleseteks.

6-9-01 Secolo XIX

"Ghosts of Mars" è quasi una doccia fredda per i fans del regista cult di "1997 Fuga da New York"

Il western sbarca anche su Marte

Carpenter diventa uno zombie travolto nella girandola di generi hollywoodiani

dal nostro inviato

Venezia Lido. John Carpenter ha mandato in vacanza il cervello. L'attesissimo "John Carpenter's Ghosts of Mars" (e già il titolo la dice lunga sui narcisismi autocelebrativi) è stato una doccia fredda per i fans - non necessariamente tutti giovani - del regista "cult" di "Distretto 13: le brigate della morte", "La cosa", "1997: fuga da New York" o del delizioso "Grosso guaio a Chinatown".

Allora: Marte 2176, ormai colonizzato da brutali e avidi terrestri. In una miniera viene scoperto un antichissimo tempio le cui viscere liberano, una volta violato l'ingresso, una sorta di nube ectoplasmica, la quale si infiltra nelle persone e ne accaparra la volontà. Non solo: trasforma i malcapitati "posseduti" in antichi, orrendi guerrieri assetati di sangue e membra umane.

Contro l'improvvisa rivincita dei marziani combatte un drappello di malandati poliziotti e un pericoloso detenuto che gli agenti dovevano trasferire. Sarà un massacro e gli unici superstiti risulteranno all'appello solo una bella e aitante bionda in uniforme, nonché il delinquente dal cuore d'oro.

L'azione si svolge su Marte nel 2176, colonizzato da avidi terrestri. Carpenter ha voluto suggellare i temi del cinema di genere, operazione riuscita a Kubrick ma non a lui

Non che manchi di idee, il film. E' buono il ribaltamento del pericolo alieno - qui sono gli indigeni a volersi riprendere casa propria - e l'idea che ammazzare gli zombies non risolva niente, anzi: immediatamente il loro spirito malvagio s'impossessa di qualcun altro che potrebbe essere il tuo compagno. Che guaio!

E' anche una curiosa "summa" di generi hollywoodiani quella che Carpenter ha rimestato in un calderone di palese cartapesta (tanto finta da apparire voluta, ma qualcuno dovrebbe ricordargli - con cautela s'intende - che non è Hitchcock), fra scoppi, corpi decapitati e squarciati, lotte all'ultimo sangue e arti marziali a volontà.

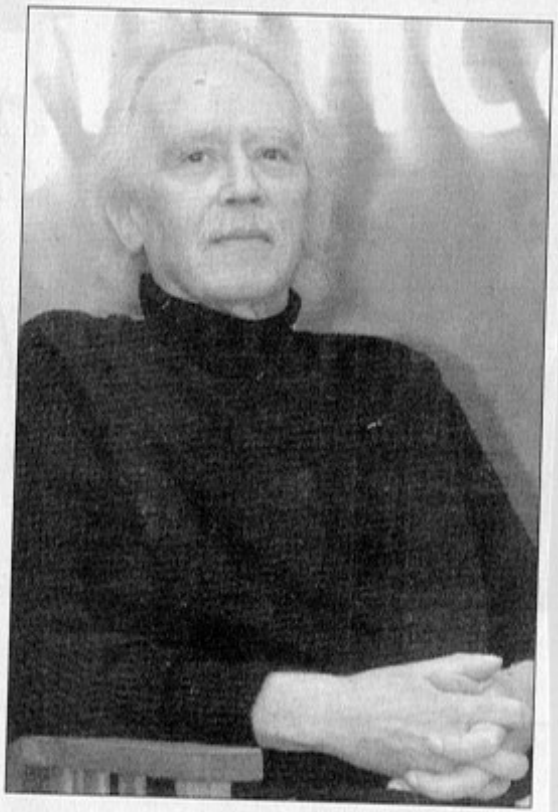
C'è davvero di tutto: dal western, rivisitato non solo nei tema dell'assedio al fortino o dell'assalto alla diligenza, ma anche in quello di una struttura a flashback che rimanda al fordiano "I dannati e gli eroi", alla fantascienza classica - come non pensare a "L'invasione degli ultracorpi" - e all'horror, naturalmente, con il prontuario di morti viventi decerebrati e ingordi di sangue fresco.

Anche l'accoppiata eroina bianca-eroe negro non è fresca di bucato, così come appare scontato l'aver appioppato i connotati rievocativi di Joanna Cassidy ("Blade Runner") alla malcapitata scienziata che non se n'è stata con le mani in tasca davanti alla porta fatale.

In ogni caso non sono i rimandi che danno fastidio: è la sensazione che Carpenter abbia voluto come suggellare - e in modo definitivo - i temi topici del cinema di genere: un giochetto che riusciva in modo eccellente a Kubrick ma che non è riuscito a lui.

Anche in questo caso qualcuno - sempre con le cautele di sui sopra - dovrebbe dirgli una parolina.

F: S.



John Carpenter regista di "Ghosts of Mars"

CORRIERE DELLA SERA
LUNEDÌ 21 NOVEMBRE 1988

Il dibattito sull'ipotesi sostenuta dal cosmologo Sciama: una tesi che portò al rogo Giordano Bruno

Molti universi? E' sempre opera di Dio

L'innovativa ammissione dell'astronomo e teologo vaticano Coyne

DAL NOSTRO INVIATO

VENEZIA — L'ipotesi del cosmologo Dennis Sciama, che ha postulato l'esistenza di una molteplicità di universi, ciascuno governato da proprie leggi fisiche, è stata fatta propria da un autorevole rappresentante della Chiesa cattolica, l'astronomo, teologo e gesuita George Coyne, della specola vaticana.

«L'ipotesi Sciama è compatibile con il ruolo avuto da Dio nella creazione; mi sento di condividerla in pieno», ci ha detto padre Coyne che è intervenuto alla giornata conclusiva del convegno sul «Principio antropico», svoltosi a Venezia per iniziativa dell'Istituto Gramsci.

Per rendersi conto del contenuto innovativo della posizione di padre Coyne basterà ricordare che Giordano Bruno fu condannato al rogo per avere sostenuto, fra le altre cose, le sue idee sulla pluralità dei mondi.

La possibilità che il nostro universo non sia unico, ma uno dei tanti esistenti, è stata presentata al convegno di Venezia da Sciama (le tesi del cosmologo sono state anticipate dal «Corriere della Sera» in un'intervista apparsa il 18 novembre scorso) con l'obiettivo di proporre una soluzione del tanto discusso «principio antropico».

Il principio è, in breve, una sorta di constatazione scientifico-filosofica sul fatto che le costanti e le leggi fondamentali della fisica, pur nella loro incomprensibile arbitrarietà, sono armonizzate in modo tale da permettere l'origine della vita e l'evoluzione dell'uomo. A partire da questo incontestabile dato di fatto si sono sviluppate in passato due opposte correnti di pensiero: una, storicamente legata alla tradizione religiosa, asserisce che la divinità ha inteso finalizzare il creato all'uomo; l'altra esclude l'intervento della divinità e attribuisce al caso l'ordinamento del nostro universo.

La tesi di Sciama è un tentativo di superamento della controversia poiché «non è necessario pensare un unico Universo, con costanti e leggi fisiche aprioristicamente determinate, ma a una molteplicità di universi in cui tutte le combinazioni fisiche che sono possibili: una di queste è favorevole alla nostra vita». Questa ipotesi non ha, secondo Sciama, un valore meramente speculativo ma, in futuro, potrà essere sottoposta a verifica sperimentale.

«Anche io non credo che Dio abbia voluto creare un Universo con tante condizioni fisiche casuali e tuttavia accordate fra loro per rendere possibile l'esistenza dell'uomo — ci ha detto Padre Coyne —. Dio è libero, non arbitrario».

«Inoltre non credo che la razza umana sia la finalità suprema dell'atto della creazione. Tutto il Creato ha un significato, non solo l'uomo — ha aggiunto Padre Coyne —. Per queste ragioni ritengo che l'ipotesi Sciama si possa conciliare perfettamente col nostro credo religioso: Dio ha creato una molteplicità di universi e poi li ha lasciati liberamente svilupparе».

Padre Coyne ammette che il suo punto di vista è molto innovativo rispetto alla tradizione della Chiesa: «Anche la teologia è una scienza — conclude — e si può evolvere dopo un confronto con le altre scienze».

A conclusione del convegno uno dei suoi organizzatori, il professor Umberto Curi, ha annunciato che gli incontri internazionali di cosmologia di Venezia si ripeteranno ogni anno con l'intento di fare di Venezia un punto di riferimento mondiale dell'evoluzione del pensiero cosmologico.

Franco Foresta Martin

nessun avvistamento

18 settembre 2001
monitoraggio Gabicce
Avvistamento luci
Ore 22, 09 due luci in sequenza e in movimento da sx a dx
Come se si fosse spenta e riaccesa a circa 1,5 gradi dalla prima,
di magnitudine -3 della durata di 5-6 secondi
Posizionata sotto la stella Auriga a 5 gr. Dall'orizzonte.

19 settembre 2001
monitoraggio Gabicce
nessun avvistamento

20 settembre 2001
monitoraggio Gabicce (vicino ristorante)
Avvistamento luci per ben 5 volte
Ore 20,25 due luci in successione
Ore 20,34 unaluce fotografata
Ore 20,44 due fotografata
Ore 20,46 1 sotto il perseo fotografata
Ore 20,54 due 5 gr. Orizzonte in verticale sotto la stella Algol fotografata

21 settembre 2001
monitoraggio Gabicce
dalle ore 20,15 alle ore 21,30 cielo sereno
nessun avvistamento

22 settembre 2001
monitoraggio Gabicce
dalle ore 20,45 alle ore 22,15 cielo foschia a banchi
(gruppo con:Lollino, Fiatti, Baccarini, Caini, Angelucci)
nessun avvistamento

23 settembre 2001
monitoraggio Gabicce
nessun avvistamento

24 settembre 2001
monitoraggio Gabicce
nessun avvistamento

25 settembre 2001
monitoraggio Gabicce
dalle ore 20,15 alle ore 22,30
nessun avvistamento
fotografato fenomeni atmosferici dal fotogr. N.10 al n. 36
il fotogramma n.25 contiene un elicottero con luce verde.

La strumentazione

che il nostro osservatorio andrà ad installare nei prossimi mesi sarà, in parte, la stessa di quella installata nella famosa blue-box, di Hessdalen. Tutto ciò è condizione essenziale per ottenere, in caso di successo del nostro programma di skywatching, gli stessi parametri utili per un confronto diretto.

Cercando di ottenere il massimo risultato con il minimo sforzo, ed in considerazione del fatto che la ricerca nelle frequenze radio rispetto a quella ottica, comporta delle differenziazioni di tipo tecnologico notevoli, anche se cambiano solo le lunghezze d'onda, la strumentazione iniziale dovrà comunque e necessariamente soddisfare tutte le esigenze del programma.
La configurazione di partenza prevede un sistema di controllo video servito da un software in grado di riconoscere ogni variazione nello scenario precedentemente memorizzato come campione e quindi in grado di salvare solo quel frame con data e ora. Questo controllo è utile da un punto di vista quantitativo e statistico, potendo lavorare anche e soprattutto in automatico ma, ha lo svantaggio di non poter offrire nessun tipo di dato scientificamente utile se non per una stima visuale del fenomeno.

La componente radio invece rappresenta la vera e propria "sorveglianza" scientifica perché dovrebbe consentirci di registrare, in caso di avvistamento, gli stessi segnali "spike" ottenuti dalla strumentazione installata a Hessdalen. Il sistema prevede una o più antenne o un sistema di antenne, appositamente studiate con un ricevitore di tipo INSPIRE con un range di frequenze da 50Hz a 110 Khz, un Computer con processore AMD 800mhz dotato di scheda Sound Blaster 32bit, software di elaborazione Grahm ed un registratore audio per l'archiviazione dei segnali.
La tendenza di questi ultimi mesi di ricerche e discussioni è quella di investire sempre più tempo e... denaro (per chi ce l'ha), in strumenti di nuova concezione che nel caso specifico riescano a coniugare efficienza ottica, velocità di puntamento e sensori CCD capaci di eseguire spettri fotometri delle luci osservate.

Tutto questo per iniziare. La strumentazione verrà implementata nel tempo e corretta a seconda delle varie esigenze che incontreremo.

ARCHEOLOGIA
La periferia di Machu Picchu
Dalle immagini aeree scattate nell'infrarosso l'archeologo Hugh Thomson ha scoperto le rovine di Llactapata, una città Inca a soli 3 km da Machu Picchu. Gli edifici orientati verso zone particolari del cielo stellato fanno pensare che fosse sede di cerimonie. Gli archeologi ritengono però che fungesse anche da magazzino e dormitorio per la città sacra vicina.

AVVISTAMENTI NELLE MARCHE DEGLI STESSI FENOMENI DAL 1985 AD OGGI

1985, 16 Agosto ore 04.45 Falconara Marittima.
Due sfere luminose fanno evoluzioni, poi si fondono e si inabissano in mare.

1985, 21 Agosto ore 20.35 Paterno di Fabriano (AN).
Un elicotterista della base aerea di falconara nota, assieme ad un'altra persona, un oggetto costituito da due sfere luminose gialle, unite.
Al di sotto, una terza, lampeggiante, rossa, piu' piccola. L'osservazione dura 20 minuti.

1985, 16 Novembre ore 23.00 Ancona.
Diversi testimoni ed un ex vigile notano dieci luci rosse che accerchiano una luce piu' grande. restano immobili per 20 minuti e poi si allontanano.

1986, 14 Agosto ore 01.00-01.30 Porto Recanati (MC).
Tre luci rosse a triangolo.

1986, 30 Ottobre notte, tra Fano e Calcinelli (PS).
Cinque luci bianche ed una luce rossa.

1986, 05 Novembre tra Gradara e Iavullia (PS),
oggetto rosso e tondo a pochi metri da terra.

1987, 05 Gennaio ore 22.00 Torrette, Ancona
globo rosso zigzagante.

1987, 18 Gennaio ore 18.30 Porto Recanati
una luce rossa che si divide in tre.

1987, 06 Marzo ore 04.30 Senigallia (AN).
4 luci di colore variabile.

1987, 24 MARZO notte, Pesaro.
Due luci arancio si inabissano in mare.

1987, 11 Maggio ore 17.00 Castelferretti (AN).
Avvistamento di un UFO. Mezz'ora dopo segnalate due luci arancio rosso in picchiata verticale.

1987, 27 Maggio ore 07.30 Numana (AN).
Bagliori sul mare.

1987, 27 Maggio ore 20.15 Torrette (AN)
Oggetto luminoso che staziona in cielo

1987, 30 Maggio dalle 22.15 alle 22.45 Massa (AN).
Globi luminosi che volteggiano nel cielo

1987, 04 Agosto sera, Ancona.
Luce rossa ferma sul mare. Notato anche un ovoide rosso - presumibilmente lo

stesso oggetto - e cinque strane luci.

1987, 19 Agosto, al largo di Ancona, ore 21
Due pescatori notano un ovoide argenteo che esce dal mare e getta bambagia silicea

1988, 23 Marzo ore 19.20 Castelfidardo (AN)
Filmata per cinque minuti una luce rossastra, vista per dieci, che fa evoluzioni nel cielo.

1988, 30 Aprile sera Apecchio (Pesaro).
Una sfera rosso blu.

1988, 01 Maggio sera, Apecchio (Pesaro).
Sfera rosso blu.

1988, Luglio Sirolo (AN).
Palle luminose si immergono nel mare.

1988, 03 Settembre ore 05.30 Ancona.
Sei punti gialli prima immobili e poi in movimento.

1997, Gennaio S.Elpidio a Mare (AP).
Notata una strana luce.

1997, Febbraio, S.Benedetto del Tonto (AP)
Luci a croce.

1998, 07 Settembre ore 19.40 Ancona.
Tre triangoli rossi si incrociano nel cielo.

ALP (anomaly lights phenomena)
Il fenomeno delle luci misteriose

Questo fenomeno non si presta ad una semplice classificazione, per la sua peculiarità a tutt'oggi non è inquadrabile in una chiara teoria scientifica in grado di spiegarne cause ed effetti.

La non convenzionalità degli avvistamenti riportati da numerosi testimoni sparsi in tutto il mondo, anche in epoche passate, ci costringe ad una statistica quantitativa del fenomeno senza riuscire a spiegarne le cause.

La catalogazione che avviene anche a livello internazionale del fenomeno possiamo riassumerla come segue:

1) **di origine Geologica**
2) **di origine microbiologica**
3) **di origine Atmosferica**

Nei fenomeni considerati di natura GEOLOGICA abbiamo

Le Spooklights
Le luci sismiche EQLs
Le Ghost lights
Le luci della terra

Per i fenomeni di origine MICROBIOLOGICA raggruppiamo i

Fox Fire

(è una luminescenza bluastro verde, che si manifesta prevalentemente nelle foreste in presenza di funghi bio-luminescenti "*mellea di armillaria*")

Fuochi fatui

(queste luci sono associate tradizionalmente alla combustione di gas prodotto da materiale organico in decomposizione di acquitrini. paludi, vecchi cimiteri, la colorazione è bluastra)

E per quelli di presunta origine ATMOSFERICA citiamo i:

- **Fuochi di ST. Elmo**

  (è una luminescenza elettrica osservata spesso intorno o in prossimità di oggetti elevati sulla superficie terrestre (alberi di navi, parafulmini, pennoni) o da aerei in volo, eliche o estremità delle ali)

- **Ball Lightnings**

  (a questa famiglia appartengono gli "spettri rossi o i getti blu". Si manifestano al contrario dei fulmini sopra le nubi con una direzione verso la ionosfera)

Luci sismiche

Molti ricercatori teorizzano che le spook lights o luci fantasma, sono causate dallo stesso meccanismo che genera le luci sismiche.

Questo meccanismo chiamato "effetto piezoelettrico" è la generazione di una carica elettrica da quarzo, quando il minerale è messo sotto pressione.

Anche se i movimenti sismici (o tettonici) nelle posizioni dove le luci compaiono, non sono abbastanza forti da causare un terremoto reale, lo sono abbastanza per innescare la formazione delle luci.

Tuttavia, questa, deve essere considerata come una teoria incompleta, poiché ci sono molte altri fenomeni connessi che la teoria stessa non riesce a spiegare:

1) Per esempio non è ancora spiegato Il meccanismo esatto attraverso il quale le forze tettoniche possano generare le luci.

2) Perchè gli Spook lights compaiono regolarmente sia nelle zone dove l'attività sismica è alta (Maco, N. Carolina USA) o completamente assente (Saratoga, in TX)?

3) Perchè gli Spook lights non sono diffusi e frequenti nelle zone come la California in cui l'attività sismica è altissima ?

4) Se l'effetto piezoelettrico del quarzo è la chiave, perchè gli spooklights non sono diffusi e frequenti anche nei luoghi con giacimenti abbondanti di quarzo?

Se lo sforzo tettonico nel sottosuolo genera l'elettricità che causa le luci, come fa questa energia ad attraversare la roccia per tornare in superficie?

Quesiti questi, ai quali è difficile dare una risposta.

Luci della terra

Vengono segnalate solitamente sotto forma di "globi di luce", "vapori luminosi", "sfere con code ardenti",
Possono anche comparire come "piume" o "fiamme", queste forme però sono più rare.
Anche se gli avvistamenti più usuali sono di globi o di sfere, questi variano molto spesso nel formato, nella luminosità, nel colore e nel diametro.

La luminosità delle luci può cambiare durante le loro evoluzioni, possono

spegnersi, sparire, pulsare o gradualmente aumentare di intensità fino ad esplodere !

I colori più frequentemente segnalati sono blu, giallo, arancione o il bianco.

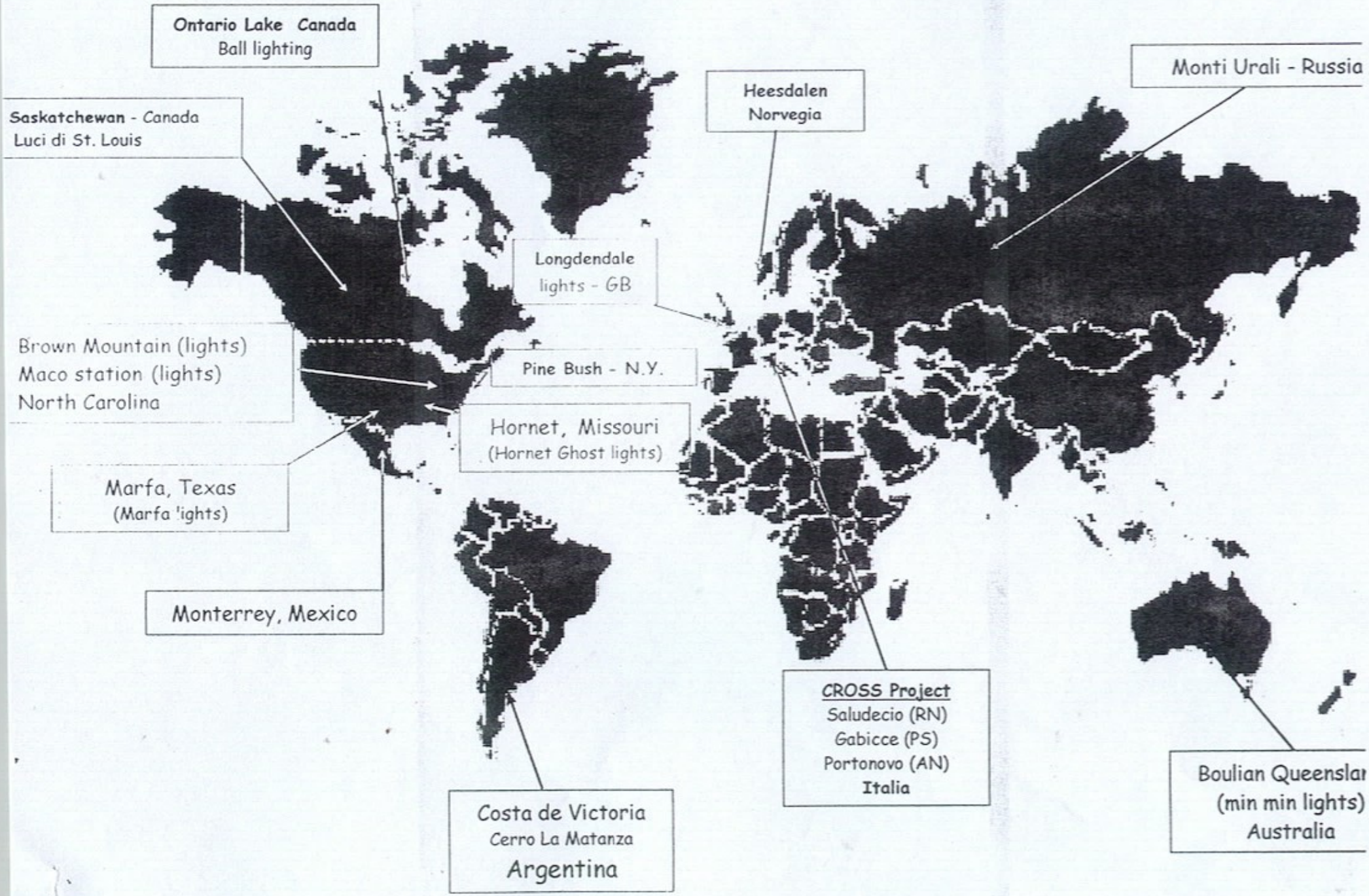
I fenomeni luminosi che avvengono in determinate aree o siti geografici mantengono sempre le loro caratteristiche e colore.
Le luci possono durare da alcuni secondi a parecchi minuti, anche se le più comuni durano circa 30 secondi.

Il movimento di questi globi varia notevolmente: fluttuano come il vapore, si muovono verso il cielo poi di nuovo verso la terra, saltano e tutti questi eventi possono accadere simultaneamente.

Tuttavia, in qualsiasi forma appaiano, rimangono sempre entro i100m di altezza circa dal terreno.

La mappatura mondiale che segue indica i principali siti dove si verificano con una notevole ripetitività i fenomeni sopra descritti:

Localizzazione siti di avvistamento



Ho aspettato per almeno un'altra ora ma il fenomeno non si è più ripetuto.
Il giorno dopo, siamo tornati nel posto con l'attrezzatura per i rilevamenti ma il fenomeno non si è ripetuto.

Monitoraggio della costa adriatica da Gabicce ad Ancona
Nei giorni dal 14 agosto al 30 agosto 2001

14 agosto 2001
Saludecio, Osservatorio astronom. Avvistate luci ore 22 circa
Dai Signori : Filippo Galeazzi e Giorgio DelBianco

15 agosto 2001
monitoraggio da Saludecio ma senza avvistamenti

16 agosto 2001
monitoraggio da Ancona Loc. Portonovo
Due avvistamenti 1- ore 22,14 di tre luci
2- ore 22,23 di quattro luci
vedere il rapporto dettagliato di F.Fiatti

17 agosto 2001
monitoraggio da Ancona Loc. Portonovo
nessun avvistamento.

18 agosto 2001
monitoraggio da Ancona loc. Portonovo
e da Gabicce Pesaro
nessun avvistamento.

19 agosto 2001
monitoraggio da Ancona loc. Portonovo
e da Gabicce Pesaro
nessun avvistamento.

20 agosto 2001
monitoraggio da Ancona loc. Portonovo
e da Gabicce Pesaro
nessun avvistamento.

21 agosto 2001
monitoraggio da Gabicce Pesaro
3 avvistamenti di luci:
1° ore 22,18 sequenza di 5 luci da sx a dx sotto la costel. Perseo a 5 gr. sull'orizzonte
2° ore 22,22 una luce spostata a dx di 10gr più a est dalla prima apparizione a 5gr. sull'oriz.
3° ore 22,28 due luci singole apparse a 3-4 secondi l'una dall'altra.....
Sono state FOTOGRAFATE

22 agosto 2001
monitoraggio da Ancona loc. Portonovo
avvistamento di una luce
ore 22,57 e 20 sec.
La luce ha fato un movimento da sx a dx per circa 2° sec.
era posizionata sotto la stella Capella a 5 gr dall'orrizzonte.
Fotografata con una macchina non adeguata.

23 agosto 2001
monitoraggio da Ancona loc. Portonovo
avvistamento di una luce
ore 22,22 luce molto piccola (forse più distante) di durata 4 sec. Ferma a sx della stella capella
Fotografata

24 agosto 2001
monitoraggio Gabicce Pesaro
avvistamento di una luce
ore 22,53 luce molto piccola a sx di Capella
fotografata

25 agosto 2001
monitoraggio da Falconara nessun avvistamento.
monitoraggio Gabicce Pesaro
avvistamento di due luci
ore 20,58 luce in basso sotto la stella Capella
ore 23,00 luce bassa sotto Capella (identica posizione?)
fotografata forse la seconda

26 agosto 2001
monitoraggio Gabicce Pesaro
avvistamento di due luci
ore 21,43 una luce singola a nord-est a 5gr. a nord del Gran carro
20gr. sull'orizzonte durata 3-4 secondi magnitudine -2.
Sembrava in movimento di discesa in verticale.
ore 21,53 una luce singola più a nord est ferma ma con le stesse caratteristiche.
Fotografate dai fotogrammi n.8 al n.12.

27 agosto 2001 Gabicce Ps nessun avvistamento
28 agosto 2001 Gabicce Ps nessun avvistamento

29 agosto 2001 Osservatorio Copernico
filmato da Giorgio del Bianco
luce singola sotto la costellazione del Pegaso

30 agosto 2001 Gabicce Ps nessun avvistamento

15 settembre 2001
Monitoraggio da Gabicce Ps
Avvistamento luce
Ore 23,03 sotto il Carro
posizionata sotto la seconda stella della coda iniziando da sx
(sospetta iridium)

16 settembre 2001
monitoraggio Gabicce
nessun avvistamento

17 settembre 2001
monitoraggio Gabicce

Questo evento fu segnalato da altre testimonianze di persone che telefonarono in osservatorio da località circostanti; in seguito le fotografie di un oggetto luminoso scattate la sera dopo, dalle quali si è potuto capire quanto questo fenomeno fosse simile alla tipologia di fenomeni luminosi che si verificano in modo ricorrente dal 1981 in una valle nord occidentale della Norvegia chiamata HESSDALEN.

Il giorno 14 agosto 2001 è la data di inizio della nuova ondata di apparizioni, periodo che curiosamente coincide con il più classico flap ufologico su tutto il territorio nazionale. Da questa data fino alla fine di settembre 2001 il controllo è stato sistematico e ha visto coinvolti, e non solo per competenza territoriale, il Coordinamento Regionale Marche del CUN (Centro Ufologico Nazionale) nella persona di Fabiana Fiatti che ha coordinato appunto gli skywatch da una postazione di Portonovo (AN).

Il numero di avvistamenti e il materiale fotografico raccolto durante questa campagna estiva è di notevole valore e ci consente per la prima volta di documentare, almeno da un punto di vista visivo-fotografico, questo fenomeno luminoso, non classificabile convenzionalmente.

Avvistamento su Ancona, di Fabiana Fiatti
16 Agosto 2001

...Di ritorno dalla Baia di Portonovo, visto che era circa l'ora dell'avvistamento del 14, mi sono fermata nel parcheggio sopra la baia, così tanto per vedere se succedeva qualcosa.
Ero a picco sul mare e davanti avevo solo cielo e mare, luci pochissime, il cielo era bellissimo, sgombro di nuvole ed umidità, anzi l'aria era freddina.
Davanti a me avevo la costellazione del Perseo, ho visto passare due satelliti, conosco il bagliore che fa l'iridium, e quello delle stelle cadenti, dei bolidi e le luci degli aeroplani, distanti o vicini che siano, degli elicotteri notturni con le loro potenti luci a faro.
Dico questo per togliere ogni dubbio sul tipo delle luci che ho visto.

Erano le 22,14 quando davanti a me,
ad un'altezza di circa 10° sul mare
poco a nord della costellazione del Perseo,
in linea retta e orizzontale, si sono come accese, in successione neanche troppo rapida,
da SX a DX, tre luci giallo arancione, grandi quasi come un faro di automobile.
Ho stimato, che tra la prima e la seconda passassero almeno 2 secondi,
e , all'apparire della terza la prima era già quasi spenta.
Credo che in tutto il fenomeno sia durato dai 5 ai 6 secondi.
Nel cielo, scurissimo davanti a me, hanno occupato lo spazio di circa 20gr, tra la prima e l'ultima, ed erano ferme.
Mentre le luci scomparivano attenuandosi, sembravano lasciare una scia di continuità fra l'una e l'altra e la cosa che mi ha maggiormente colpito era il perfetto allineamento in orizzontale, come se non fossero tre oggetti diversi ma legati da un qualcosa tra loro o appartenere allo stesso oggetto.
Ribadisco però che le luci erano fermissime, come dei fari improvvisamente accesi al massimo della potenza e poi lasciati spegnere più lentamente. Ma diversamente dai fari la luce era compatta rotonda senza sbavature nella circonferenza.
Dopo esattamente 9 minuti alle 22,23 il fenomeno si è ripetuto.
Questa volta spostato a SX di circa 25° dalla prima apparizione,
e con un allineamento leggermente in diagonale ma sempre perfettamente allineate.
Le luci sono state 4 e questa volta da DX a SX, identiche alle prime ma all'apparizione della quarta la prima era completamente spenta ed ho avuto la sensazione che la questa durasse un tempo superiore alle altre e con maggior luminosità.
Lo spazio occupato in cielo era di circa 30°, il tempo invece l'ho stimato sugli 8 - 9 secondi.

GianFranco Lollino
Direttore Osserv. Copernico

Osservatorio Astronomico
Gruppo Astrofili N.Copernico
S.Maria del Monte - SALUDECIO (RN)
WWW.COPERNICO-ONLINE.ORG

Fabiana Fiatti
Coordinatrice CUN
Marche

IL "CROSS PROJECT"

Ovvero Copernico Radio and Optical Skywatching System, rappresenta una delle novità più interessanti che il nostro osservatorio ha presentato recentemente, in più consessi.
Il progetto CROSS è nato a seguito di una fitta serie di incontri avuti durante l'estate 2000 con l'astrofisico Dr. Massimo Teodorani, Prof. Stelio Montebugnoli (dirigente Tecnologo CNR-IRA, direttore del SETI Italia) presso il Radiotelescopio di Medicina (BO), in particolare dopo la spedizione strumentale effettuata nella località norvegese nell'Agosto 2000, denominata EMBLA.

Il Cross Project ha l'obbiettivo primario di verificare se gli avvistamenti che si verificano nella nostra regione e nel territorio nazionale, hanno le caratteristiche di ripetitività e/o periodicità e, in caso affermativo, stabilire delle correlazioni con la casistica mondiale ed
In particolare stabilire uno standard di misurazioni con le stime effettuate dalle varie spedizioni scientifiche in Norvegia, durante le quali sono state messe a punto e testati nuovi analizzatori di spettro multicanale che, collegati ad antenne di nuova concezione, hanno permesso di captare anomali e incomprensibili segnali radio durante l'apparizione dalle misteriose luci.

Il progetto in sintesi è stato concepito per monitorare la nostra zona geografica sia con ricevitori radio nella banda VLF sia con sistemi di rilevamento ottici, al fine di stimare e quantificare la presenza di certi fenomeni luminosi che da qualche tempo si rendono visibili in ore prevalentemente notturne.

il Cross Project sta registrando una ripresa delle segnalazioni e avvistamenti delle peculiari luci che contraddistinguono la nostra area geografica.
Stiamo fronteggiando questa ondata di avvistamenti con in sistemi tradizionali, ottici e video, nella speranza di quantificare numericamente, oltre che visivamente, questo fenomeno davvero singolare ed interessante.

Nella convinzione di trovarci di fronte ad avvistamenti, per caratteristiche, molto simili al fenomeno norvegese di Hessdalen e/o canadese del lago Ontario, avevamo preso come riferimento alcuni parametri fisici annoverati fra le "costanti", stimate durante le campagne osservative in terra norvegese come temperatura, periodo e fasce orarie preferenziali per gli avvistamenti.

le ultime segnalazioni risalivano al gennaio del 1997, con l'avvistamento di una serie di globi luminosi insoliti da parte di due astrofili del nostro osservatorio, la sera del 15 gennaio 1997

- Evidence of volcanic activity on Io.

Io

Image of the moon Io taken on an orbit in February two of Io in 1999.

NASA is already studying some 1,800 images sent back to Earth during Galileo's primary mission, including high-resolution pictures of the biggest Jovian moons.

The Europa mission is designed to follow up on previous discoveries and will include eight consecutive fly-bys through February 1999, followed by four of the moon Callisto and one or

"The Galileo Europa mission really build upon the success of the prime mission, which has forced us to rethink many of our perceptions of the Jovian system," said Galileo project scientist Torrence Johnson.

"Jupiter dished up some nice juicy surprises," he said.

After the current mission looks at Europa, it will go on to look at Io and Callisto late next year.

Correspondent Rick Lockridge and Reuters contributed to this report.

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GIORNO 10-8-91

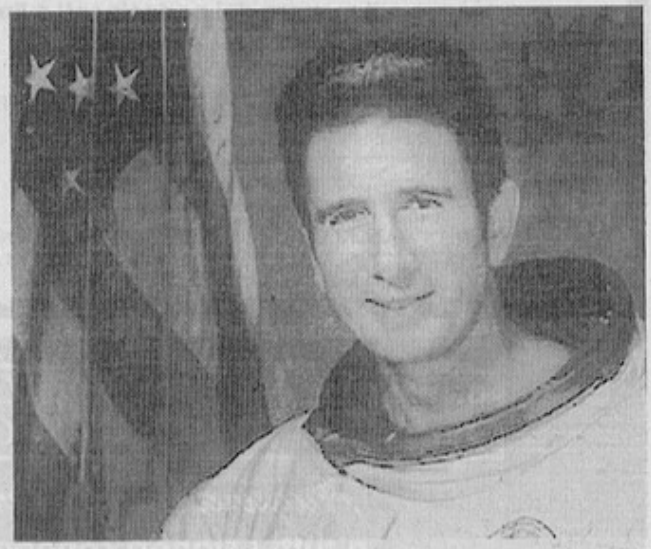
Fu il primo a guidare un automezzo sul satellite

E' morto l'astronauta James Irwin pilota sulla Luna, mistico sulla Terra

WASHINGTON – E' morto l'astronauta americano James Irwin, che nel 1971 fu l'ottavo uomo a mettere piede sulla luna e il primo a muoversi con un veicolo elettrico sulla superficie lunare. Irwing, che aveva 61 anni, vent'anni fa partecipò alla spedizione «Apollo 15» e rimase sulla luna per più di tre giorni.

Le passeggiate lunari compiute nel 1971 cambiarono la sua vita: James Irwin percepì in quell'occasione per la prima volta la «presenza di Dio», la «fragilità del pianeta terra e la necessità di proteggerla». Dopo quell'esperienza, decise che la sua nuova missione sarebbe stata la diffusione dei vangeli: fondò la «High flight foundation» per portare nel mondo la parola di Dio e cominciò pellegrinaggi annuali al monte Ararat, in Turchia, per cercare l'arca di Noè.

La storia di Irwin è segnata in modo suggestivo dall'episodio più esaltante della sua carriera professionale. Nato a Pittsburgh nel 1930, Irwin guadagnò nel 1957 un master in ingegneria aeronautica. Dopo molti anni alla Nasa, fu scelto nel luglio del '71 per far parte dell'equipaggio dell'«Apollo 15 endeavor» insieme ad Alfred Worden e David Scott.



L'astronauta americano James Irwin. (Foto Ap)

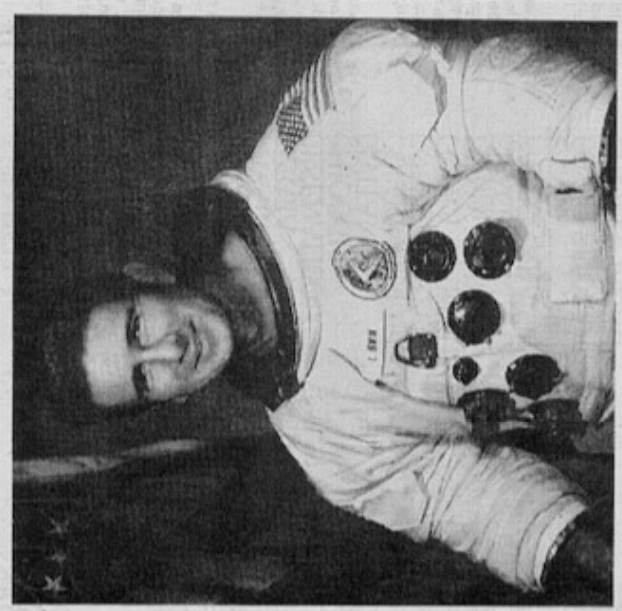
Scott e Irwin passeggiarono sulla luna per un totale di 17 ore e 11 minuti, raccogliendo esemplari di rocce lunari e compiendo esperimenti vari. Ma per Irwin ebbe un significato superiore a quello scientifico: «la cosa più commovente – disse al ritorno – è che mentre ero lì ho sentito la presenza di Dio».

Sulla superficie lunare – raccontò – la bellezza dell'universo gli apparve in tutta la sua evidenza.

La spedizione dell'«Apollo 15» ebbe anche qualche momento di tensione: durante lo splashdown, infatti, uno dei tre paracadute della navicella non si aprì, facendo temere per l'incolumità dei tre astronauti, ma senza conseguenze.

10-8-91

È morto James Irwin astronauta mistico



GLENWOOD SPRINGS (Colorado) — L'ex astronauta James Irwin, uno dei 12 uomini che toccarono il suolo lunare con le missioni Apollo, è morto all'età di 61 anni per un attacco cardiaco. (Gli altri 11 componenti delle missioni Apollo che raggiunsero la Luna sono ancora tutti vivi). Irwin divenne noto come «l'astronauta mistico».

Le tre passeggiate lunari compiute nel 1971 cambiarono la sua vita: James Irwin, come egli disse, percepì in quell'occasione per la prima volta la «presenza di Dio».

Dopo quell'esperienza, l'ottavo uomo a mettere piede sulla Luna (ed il primo a guidarvi un automezzo), decise che la sua nuova missione sarebbe stata la diffusione dei Vangeli: fondò la «High Flight Foundation» per portare nel mondo la parola di Dio e cominciò pellegrinaggi annuali al Monte Ararat, in Turchia, per cercare l'Arca di Noè.

GIORNALE DI BRESCIA

Next stop Mars

MARS HAS THE MOST extraordinary power to fuel the imagination. From Jules Verne and his *War of the Worlds*, to popular films like *Total Recall* and, yes, even *Mars Attacks*, the Red Planet has inspired some out-of-this-world drama. Yet in the past year the quest for hard facts about Mars has eclipsed even the best science fiction.

It all began last year, when researchers announced that Mars may once have supported life, and that the evidence—a meteorite chipped off Mars—landed on Earth some 13 000 years ago. In July, Pathfinder bounced into a dried-up flood plain and let loose a rover. The event created a frenzy in the media, and tens of millions of people logged onto NASA Web sites to follow events. Since then, Pathfinder and its rover have been busy. In "Postcards from another planet" (p 38) you can see some of the best images and data these robots have sent back.

There is more to come. Global Surveyor grazed the Martian atmosphere last week. And NASA has promised to send two spacecraft to Mars every 18 months from now on. A key question that planetary scientists hope to answer is why Mars turned from a warm, wet paradise into a barren, frozen desert, and whether a similar fate could be in store for Earth. "Death of a watery world" (p 34) explores their strategy for doing this.

These craft will also pave the way for human interplanetary flight. Whether anyone actually travels to Mars is still wide open. NASA is uncommitted. But it is designing its missions to study problems that must be solved before anyone gets to go.

Unlike robots, people need oxygen, heat, food and a way to get home. That will make a human mission hugely expensive. The cheapest round trip is estimated at $20 billion, compared with the $150 million or so each for Pathfinder and Global Surveyor. And there are plenty of critics who ask what humans can do on Mars that robots can't.

Then there are the risks. Little is known about the effects on humans of interplanetary travel. It is clear from "2011: A Mars odyssey" (p 28), that the journey to Mars would leave astronauts seriously weakened. Perhaps one of Pathfinder's successors would give a human crew weakened by months in space a real run for their money.

The human desire to explore and conquer is not going to go away. Early next century, a select group of scientists, technologists and politicians will have to decide whether to ask a human crew to suit up, ready for a mission to Mars. They could play safe, and stick with robots. Or they might take a giant, imaginative leap for mankind . . .

A Mars odyssey

Explorers setting off for the Red Planet must survive and stay healthy for two years or more in the harsh conditions of space. *Robert Taylor* follows their fate

July 20, 2011, Kennedy Space Center, Florida. Explorer I blasted off for Mars at dawn today. The Explorer, with its crew of three men and three women from four nations, will land on the Red Planet in six months, and head home only after an 18-month exploration of its surface. "We have complete confidence in our equipment and our ground support team," said mission commander Nathaniel Ramirez. "Now it's up to us..."

If NASA had a nickel for every science fantasy about humans exploring Mars, it could send the entire US astronaut corps to the Red Planet, first class. But science fact may catch up with science fiction sooner than you think. People could walk on Mars within 15 years, say space scientists in the US and Russia who are busy sketching out plans in anticipation of getting the go-ahead. "Sending people to Mars is a great challenge, but not an impossible one," says Lewis Peach, who oversees planning of NASA's "reference mission" to Mars at the Office of Space Flight in Washington DC.

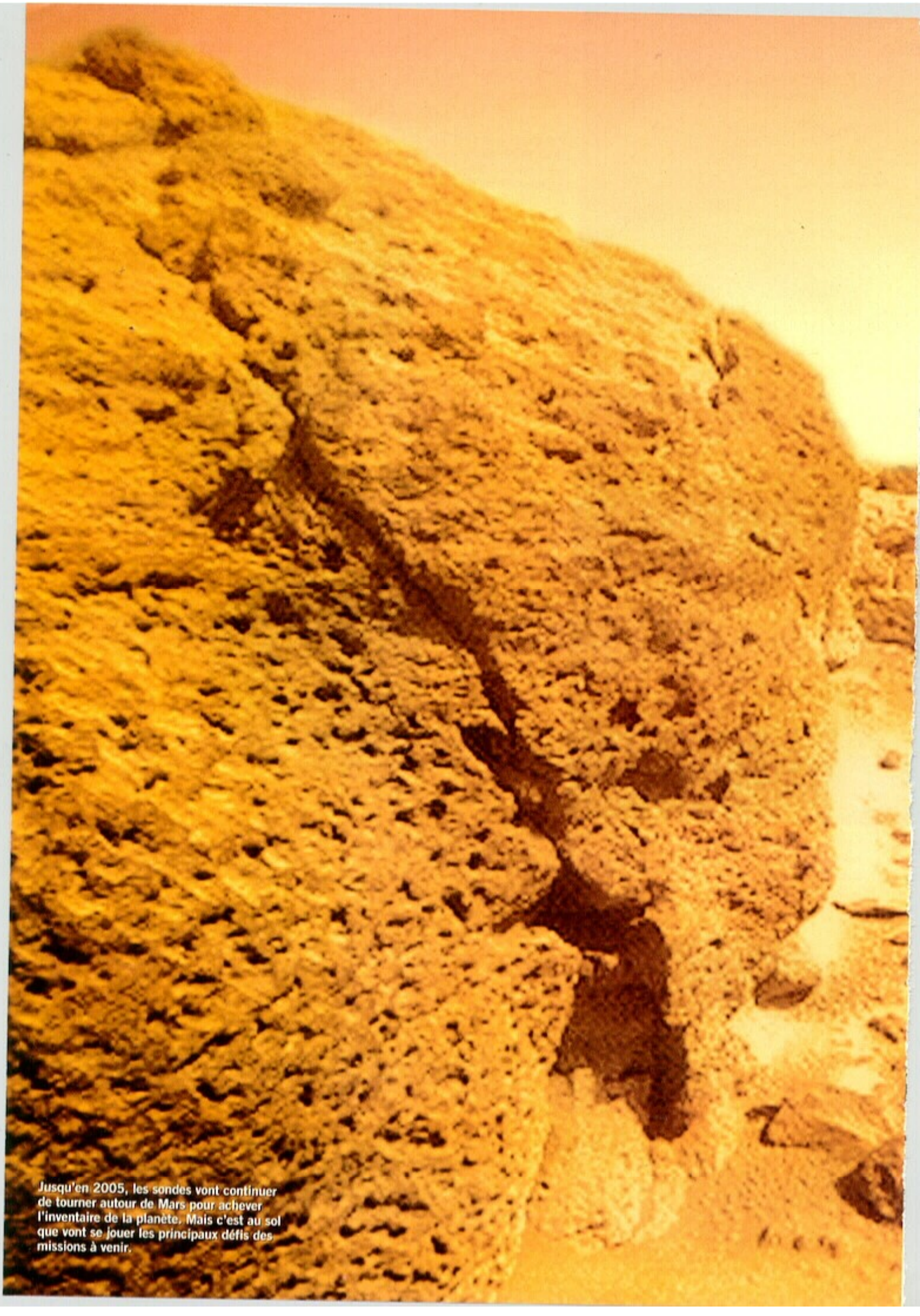
There is, however, one potential trouble spot: the "people" part. The astronauts will be the most complex and least understood system on a Mars mission, and keeping them safe, warm, and happy for the duration will be a tricky technological feat.

Tricky. But with a little forward planning, doable.

October 4, 2011, Korolyov, Russia. An intense solar flare forced the crew of Explorer I to take refuge in their on-board radiation shelter, flight controllers reported today. The crew is in no immediate danger, but must remain in the closet-sized shelter until radiation levels abate, which may be several days. "I am glad that we are all good friends," said systems specialist Elisabeth Schweitzer-Maier...

Space is a hot place. Outside the Earth's protective atmosphere and magnetic field, atomic nuclei zip along with as much as 1 gigaelectronvolt of energy. When these cosmic rays strike flesh they blow biological molecules to bits. They also generate electrons and gamma rays when they hit anything solid, be it human skin or the spacecraft. For added excitement the Sun throws out a solar flare once every year or

Illustrations: Chris Draper



Jusqu'en 2005, les sondes vont continuer de tourner autour de Mars pour achever l'inventaire de la planète. Mais c'est au sol que vont se jouer les principaux défis des missions à venir.

so. These eruptions generate huge doses of high energy protons that would kill unprotected astronauts within hours.

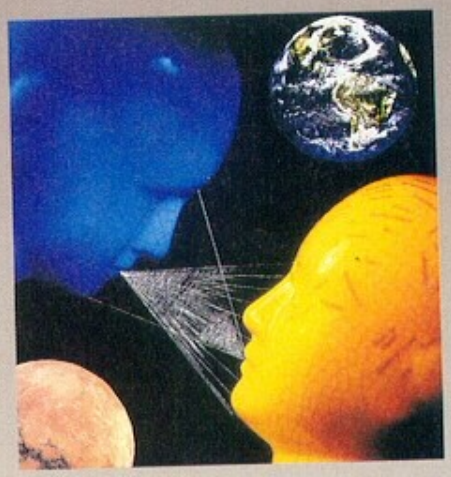
The Mars spaceship will need shielding, shielding means more mass, and more mass means more money for more rocket. For that reason, only a small room at the heart of the ship will be heavily protected, and much of that protection will come from clever positioning of supplies. Astronauts will retreat to this "storm shelter" if a flare hits during transit. Otherwise, they will rely on the skin of their ship to block most of the routine rain of smaller particle radiation; there is no practical way to keep out heavy nuclei.

Once the crew reaches Mars, their nuking is far from over. The thin Martian atmosphere and insignificant magnetic field are poor protection, although the planet's bulk will reduce the cosmic ray dose. Sandbags thrown up on the habitat's roof would help, too.

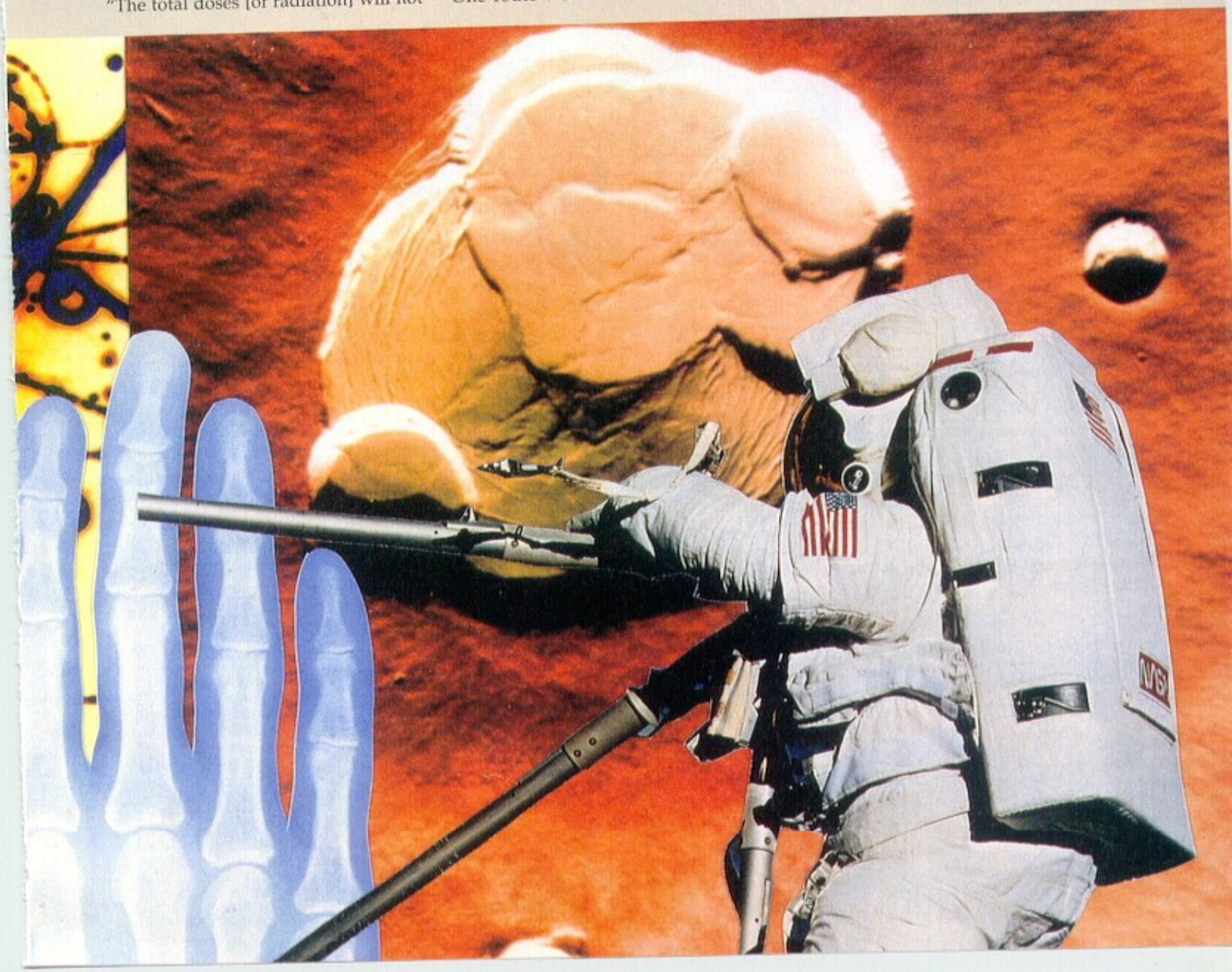
"The total doses [of radiation] will not be negligible," says John Dicello of Johns Hopkins University in Baltimore. Dicello was on the panel of the US National Academy of Sciences (NAS) that released a report on the radiation risks of lengthy space flights late last year. Just as explorers on Earth used to take for granted the risks of snake bite, scurvy, and shipwrecks, interplanetary explorers may have to accept a higher cancer risk as part of the deal.

But how much higher? Over their whole careers, NASA astronauts, and those who will fly on the International Space Station (ISS), should be exposed to no more radiation than that estimated to increase the risk of dying from cancer by a minuscule 3 per cent, says Tracy Yang, a radiation safety officer at Johnson Space Center in Houston. Mission planners say that they will aim for a similar figure for the astronauts who travel to Mars.

Achieving that goal will not be easy. One route would be to turn down any



potential Mars explorers whose genes may predispose them to radiation-induced cancer. Some genetic profiles—certain versions of genes like *ATM* or *BRCA2*—could increase that risk. And, of course, by the time a Mars rocket is ready to go, testing for genetic susceptibility to



cancer will be down to a fine art. But using information about genetic risk is just as touchy a topic for NASA as elsewhere. According to Yang, medical information is only currently used to make astronauts aware of their risk, and not to bar them from any activity.

Then there's the problem of how to predict just how nasty cosmic radiation might be. At the moment, estimates are based on what is known about the effects on the body of gamma rays and X-rays. But the real risks from cosmic radiation could be higher or lower by as much as a factor of fifteen, says Dicello. And cancer may not be the only side effect of radiation exposure. For example, practically nothing is known about how the nervous system will withstand a three-year cosmic ray shower—it would not look good if the crew developed a mysterious dementia when they got back home.

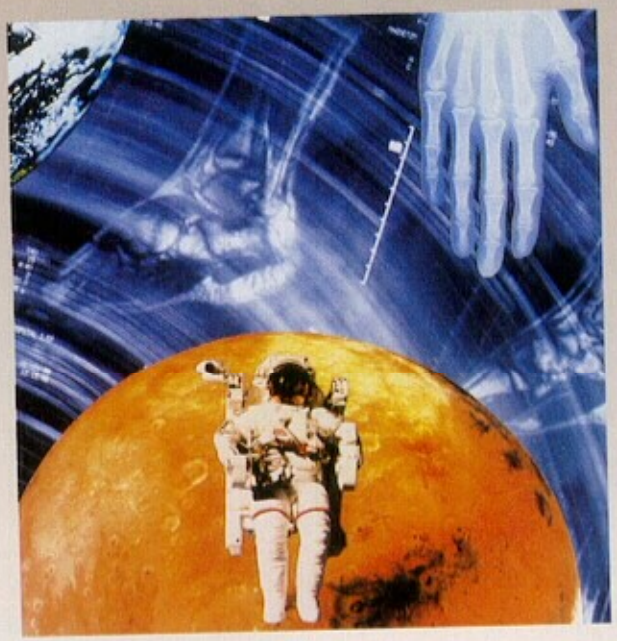
To clarify the danger from radiation, the NAS report urged NASA to buy or rent a heavy particle accelerator, so they could find out what happens when you zap human cell cultures and animals with high energy particles. If these experiments show that the human body is less susceptible to cosmic radiation than experts have feared, the savings on shielding would be astronomical, the NAS points out.

January 27, 2012 Johnson Space Center, Houston. After a harrowing landing, the Explorer I crew is safe in their habitat module placed on Mars two years ago. A faulty thruster pushed the ship 3 kilometres from its target site, where it overturned on a boulder-strewn plain. Only fast action by geochemical science specialist Valentina Kondekova, the one member of the crew able to walk more than a few paces in the first hour after landing, saved the mission.

After stabilising a leak in the emergency oxygen generator, Kondekova walked and crawled to the habitat, returning in the habitat's rover to rescue the others...

"Use it or lose it" is nature's iron law of fitness. And when astronauts live in microgravity, they lose it in buckets. For the first few days in space, "losing it" takes its most conspicuous form—nausea and vomiting hits most space travellers, and hits them hard. But almost all astronauts get their space legs in a few days.

The long term effects of microgravity



are more insidious. Muscles and bones decay, and every physiological system that takes a cue from gravity gets subtly out of whack. For example, the heart can lose its rhythm—witness the arrhythmia suffered by Vasili Tsiblieyv this summer in the waning days of his Mir tenure.

These changes make coming down again particularly unpleasant, even dangerous—blood pressure plummets as gravity pulls your blood back down to your feet. "In the first four to six hours you can't do very much, especially in the way of picking things up," says NASA astronaut John Blaha who spent four months aboard Mir.

A Mars crew will make this transition twice. First on Mars—Martian gravity is 38 per cent that of Earth—and again on their return home. One of the problems in predicting the impact of reduced gravity is that no one knows how well Martian gravity will help preserve the astronauts' normal physiology. That, and the fact that people vary enormously in their responses to changes in gravity. Valeri Polyakov shocked everyone by climbing out of his Soyuz capsule and walking, albeit shakily, after a record 14 months in space. Polyakov—no surprise here—is confident that astronauts would adapt easily to Martian gravity.

Mars explorers won't be allowed to go to seed as they float to their destination, either. Like the residents of Mir, they will follow an exercise regimen designed to ward off the worst effects of microgravity. Marathon runners and returning Mir cosmonauts alike often have poor "orthostatic tolerance"—they cannot maintain their blood pressure while standing still for long periods, says Inessa Koslovskaya, chief of neurophysiology and countermeasures at Moscow's Institute for Biomedical Problems. Weight lifters, on the other hand, have great orthostatic tolerance, she says. So the Mir exercise programme is designed to maintain strength—the ability to sprint and to lift heavy weights (in microgravity, the ability to stretch bungee cords)—rather than aerobic endurance, which has been the main target of the exercises used by astronauts on shorter NASA space flights. The problem, says Koslovskaya, is convincing spacefarers to work out. "Cosmonauts prefer to work with their heads."

But perhaps the threat of crippling bone loss on a trip to Mars would motivate them. Most of the physiological changes

1·5 m–100 000 years ago

Early humans set out from Africa to explore Europe and Asia

14 000 years ago

Hunter-gatherers take advantage of a drop in sea level to cross the Bering land bridge that connects Asia with the American continent

510 BC

Hanno of Carthage (near modern Tunis) explores the West African coast. He returns with exotic animals and tales of creatures like gorillas

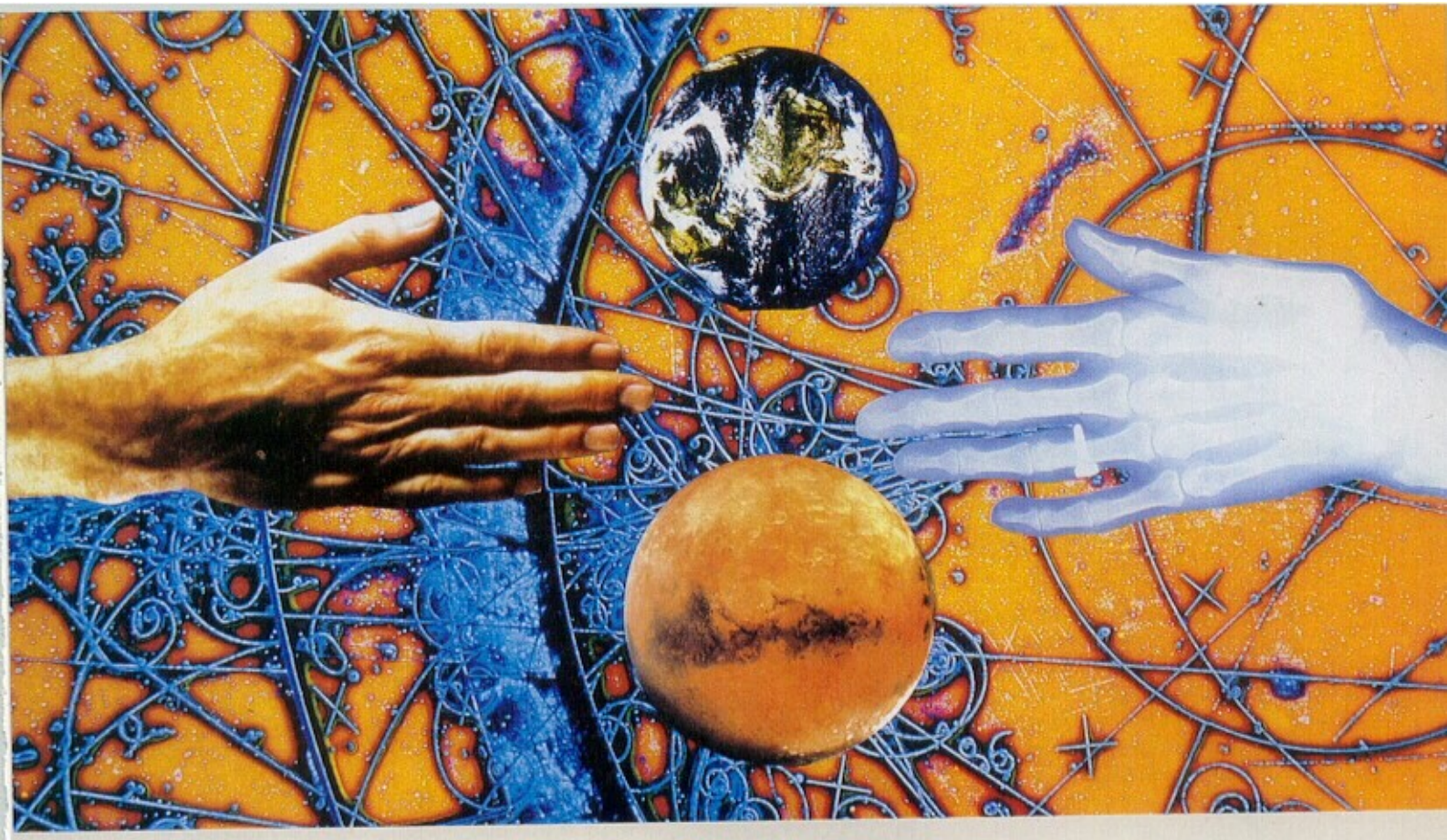
330 BC

Pytheus of Masilia sails from France to Ultima Thule (modern Iceland or Norway), 6 days north of Britain and 1 day short of "the end of the world". He returns with stories of a "midnight sun". No one believes him

AD 1295

Marco Polo returns to Venice after exploring China for 17 years. But many of the new words he learnt were Persian, not Chinese, and he seems to have missed some major landmarks like the Great Wall. Some scholars now question whether he ever made it to China. Nevertheless, his descriptions of Eastern riches inspired other explorers

Compiled by: Neil Bryce



measured in Mir cosmonauts stabilise at around 3 months. Bone loss, however, continues at a rate of 1 to 2 per cent per month. And so far it's not clear whether any of the countermeasures used on Mir or the US space shuttle have helped, says Adrian LeBlanc who conducts NASA-funded research into muscle and bone loss at Baylor College of Medicine in Houston. Stressing bone to the limit in combination with drug therapy may be the only way to keep bones strong, he says.

To test his theory LeBlanc is studying 30 volunteers on bed rest, in which bone loss closely mirrors that seen in space. Once a day, ten volunteers will do a few sets of exercises with as much weight as they can lift, increasing the load and number of sets as their strength increases. Ten volunteers will take alendronate, a drug used to treat osteoporosis. Ten other slug-a-beds will skip both the exercise and drugs, and serve as controls. LeBlanc is monitoring the volunteers' bone density with an X-ray scanner, and following calcium balance by analysing urine and blood serum. If neither the exercise nor the drugs work, nor both together (which is what LeBlanc will test next), "I don't know what will," he says.

Perhaps high frequency vibrations. Studies on bird, sheep, and human bones suggest that high frequency vibrations promote bone formation, although no one yet knows how. Allen Goodship at the University of London is now testing that hypothesis on Mir. The cosmonauts exercise on a resistive "stepper" similar to the ones found in gyms but with a gizmo on one footplate that whacks the user's heel when the leg is fully extended, setting off a spike of vibration in the bones; the other leg is the control.

"One cosmonaut has used it so far, for about 15 minutes per day, and he rather enjoyed it," says Goodship. What's more, the bone densities of the cosmonaut's untreated heel and shin bones fell by up to 7 per cent during the flight while the treated leg lost no bone, although the beneficial effect did not reach as high as the hip. Goodship hopes to get more cosmonauts to give his heel whacker a try.

April 12, 2013 Johnson Space Center, Houston. Explorer pilot and biology specialist Hashiro Okazaki returned to full duty status today after a two-week "recuperation period". Okazaki broke his ankle two months ago when he tripped over a cable. In a statement released today he denied reports that he has become uncooperative and depressed. "I appreciate [the] concern, but I need only rest," he said. "Really..."

Imagine camping out with five companions in a largish caravan. Might be fun. Now imagine that the trip lasts two years or more. And you're 100 million miles from home. And you can't go outside without elaborate preparation. And it's dusty and cold out there anyway, and

AD 1492

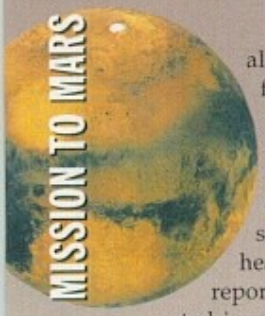
Christopher Columbus sets out to cross an ocean that's bigger than he ever imagined. Shortages of food and fresh water drive his crew close to mutiny. They finally land in the Bahamas, but until his dying day, Columbus believes he had reached the Far East

AD 1768-71

In search of the fabled southern continent, Terra Australis, James Cook sets out in the Endeavour, taking British astronomers along to view the transit of Venus across the Sun in 1769. He successfully combats scurvy and charts the coast of New Zealand and the eastern coast of Australia

AD 1804-06

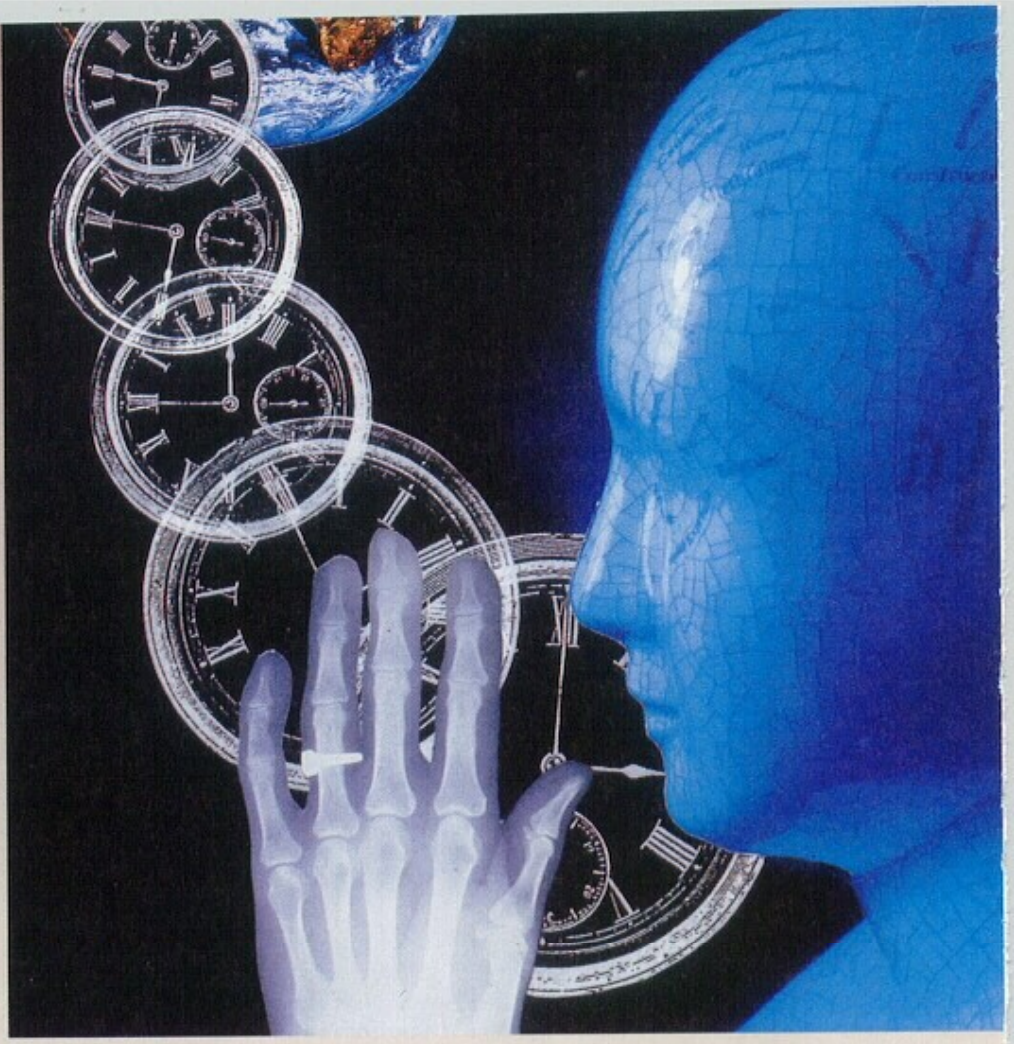
Meriwether Lewis and William Clark cover 8000 miles of the uncharted American West. The team of 45 men and one woman suffers constant food shortages, capsised boats, and intestinal problems from eating boiled roots. Two men desert the expedition, one gets discharged for mutiny, and Lewis and Clark enforce discipline by flogging the others



always the same. And the food is boring. And a single mistake could cost all your lives. And communications home have a 40-minute delay between saying something and hearing a reply. And the TV reporters don't seem that interested in you any more. And one of your companions picks his teeth all the time with his fingernail. And he doesn't even say excuse me. And if he does that one more time, you're gonna pick up this spare oxygen tank and…

A trip to Mars is not for the faint of heart. The crew will be isolated, confined, with no hope of resupply or early return—the planets' orbits are such that a launch window only opens once every two years. NASA's current plan calls for a six month transit to Mars, and six months back, with perhaps an 18 month stay on Mars. Low morale or bad group dynamics—not to mention depression or other mental disorders—could be catastrophic.

But explorers have survived incredible hardships before, and could do so on Mars, says Jack Stuster, a NASA-funded researcher with ANACAPA Sciences, a company in Santa Barbara, California. Stuster's book *Bold Endeavors* explores what space flight can learn from polar exploration. Selecting the right people will be half the battle. Competition for a berth will be fierce, but the ideal candidate will not be a hyper-achieving, single seat fighter pilot, as many astronauts have been in the past. Instead, says Stuster, the perfect Mars explorer will have experience on small teams facing difficult tasks. Someone like William Shepherd, named last June as the first ISS commander. A veteran of two shuttle flights, Shepherd spent ten years in the US Navy SEALs and other elite special forces units. "An ability to subordinate one's own interests to the group's, is a core SEAL value," says Stuster. This is just the kind of right stuff a Mars explorer will need.



While people in isolated research or space stations rarely lose their heads completely, specific emotional problems crop up again and again, says Stuster. Workers often feel forgotten by the folks back home. They can develop an us-versus-them antagonism with mission control, which could lead to outright mutiny. Astronauts on the third US Skylab mission in 1974 got so irritated with ever escalating demands from the ground that they unilaterally took a day off. Stuster says that in the aftermath, the astronauts and mission controllers had "the first sensitivity session in space". The isolation can also induce lethargy, depression, or paranoia. And sparks tend to fly easily among people cooped up under harsh conditions; on two occasions a Russian crew on Mir came home earlier than planned because the cosmonauts just couldn't stand each other anymore, Stuster says.

Training for space station astronauts has begun to take into account social and psychological stresses, and includes conflict resolution techniques and training in the cultures of fellow crewmates, says Frank Hughes, director of space flight training at Johnson Space Center. There are also plans for a "crew support system" on the ISS that will include a laptop computer each, books, videos, educational programmes and provisions for private communication with home and individual counselling. Hughes acknowledges that the plans for crew support on the ISS are "embryonic" compared to the elaborate preparations needed for Mars explorers.

The risk of depression (and other dis-

AD 1911

Roald Amundsen's team plants a Norwegian flag at the South Pole, and leaves a letter for the Briton Robert Falcon Scott, who arrives a month later. Brokenhearted, weighed down with scientific equipment, and lacking sled dogs, all five men in the British expedition perish on the return trip

AD 1930

To explore the undersea world, Charles William Beebe and Otis Barton drop over 400 m in a spherical steel cabin tethered to a ship. They observe marine life never before seen by divers. Had the cable snapped, they'd have sunk to the ocean floor with no way to return

AD 1957

David Simons, a US Air Force surgeon, ascends 31 110 m in a balloon and stays there for 32 hours to study the effects of high altitude on human health

AD 1968

US astronauts Frank Borman, James Lovell and William Anders see the dark side of the moon on the Apollo 8 mission

orders like excessive fatigue, insomnia, headaches, and diarrhoea) also goes up when the body's circadian rhythms are upset. Circadian rhythms are cycles in hormone levels, body temperature, and other physiological changes, that are usually synchronised with the 24-hour Earth day. Mission planners will have to work out how to keep the astronaut's rhythms healthy as they move to a 24 hour and 37 minute "day" on Mars. "Light is the most important synchroniser for circadian rhythms," says circadian biologist Derk-Jan Dijk at Harvard Medical School in Boston. Mars is brutally cold, and the astronauts will be living in extremely well-insulated quarters which probably won't let in much natural light. Dijk thinks it likely that humans will be able to adjust to long periods of time on 24·6 hour days. But, he says, more studies are needed to work out exactly how to use artificial lights to keep Mars explorers in-synch with Mars.

"We are breaking with our scheduled programming to bring you this news report. NASA has just announced that Rachel Blackwell, Explorer's electrical systems specialist, died yesterday of a kidney infection. Explorer 1 is due to splash down on 18 December, less than two weeks away. Doctors believe the infection, symptoms of which only appeared three days ago, progressed explosively because Blackwell's immune system had been weakened by prolonged stress and radiation exposure. Blackwell, like her crewmates, was also seriously dehydrated due to the failure of the water recycling system..."

People get sick, and the crew of a Mars mission will be no exception. Sure, they'll be quarantined for weeks before they set off. And they'll be checked and rechecked for every disease known to humanity, their appendixes will likely be removed (just in case), and their genes and family histories probed for hints of a predisposition towards cancer, cardiovascular problems and mental instability. But they will be under constant physical and emotional stress, so their immune systems may not be in peak condition. That could make them susceptible to the normally benign organisms that inhabit every human body. Then, there's the possibility of accidents.

To cope, the crew will have medical supplies—essential drugs, diagnostic equipment, bandages, sutures and other basics—and very likely a doctor on board to do diagnosing, dispensing, bone-setting, and stitching up. But what if you need more? Say, an expert's opinion on whether an astronaut's chronic malaise is just fatigue or the forerunner to an impending medical catastrophe. Exactly how well equipped the ship's sick bay needs to be is open to debate.

Arnauld Nicogossian, NASA Associate Administrator for Life Sciences, outlines a medical system that includes continuous, noninvasive monitoring of each crew member's vital parameters like heart rate; miniaturised X-ray scanners and other diagnostic equipment; and arrays of biosensors to measure everything from contaminants in the air to microorganisms in the water. And, he says, shipboard data will have to be accessible to experts back on Earth so that they can provide the best possible medical advice.

Let's not get carried away, says Robert Zubrin, president of Pioneer Astronautics, an aerospace consultancy in Indian Hills, Colorado. "Explorers have always accepted risk," says Zubrin, who in the early 1990s outlined a Mars plan which now underpins NASA's ideas. For a Mars team, risk includes the fact that the nearest casualty department is on another planet.

According to Zubrin, even a full-time doctor is an unaffordable luxury. "You want a crack electrical engineer who knows some medicine rather than a doctor who has done some ham radio," he says. As for a doctor whose job would be to study the other crew members in the interests of learning more about space medicine, forget it. "He'd be out the airlock in three weeks—astronauts don't like to be studied."

Zubrin also claims that the biggest risk to the crew's lives will not come from a medical emergency—or radiation or microgravity or mayhem by a crazed crew mate—but from unforeseen mechanical failures. He has a point. No need to worry about cancer in your declining years if the rocket blows up. And any machine—be it for water recycling, air purification, communications, navigation, or the engines themselves—can break down, especially during a long mission that will strain the hardware in unimaginable ways.

No matter how well planned, the danger will be great. So why not send robots instead of humans? For reasons that go far beyond immediate practicalities, says Zubrin. "Mars presents the challenge of a new frontier, a place we can plant a new branch of human civilisation," he says. "For that, you need people."

January 28, 2014, Arlington National Cemetery, Virginia. In a sombre ceremony, Explorer hero Rachel Blackwell was buried here today. Engineers at Marshall Space Flight Center in Alabama have identified the mutant fungus that destroyed the bacterial cultures used for water recycling, and which indirectly led to Blackwell's fatal infection. "As we mourn our loss today, we must remember," said President Karenna Gore, "the future belongs to the brave." □

Robert Taylor routinely has *Star Trek* dreams

AD 1969

Neil Armstrong walks on the moon...and fluffs his famous line: "That's one small step for [a] man, one giant leap for mankind." Armstrong and Edwin Aldrin gather soil samples, set up a laser beam reflector that measures the distance to Earth, and conduct a solar wind experiment. Many Americans reportedly still believe that NASA faked the whole thing

AD 1977

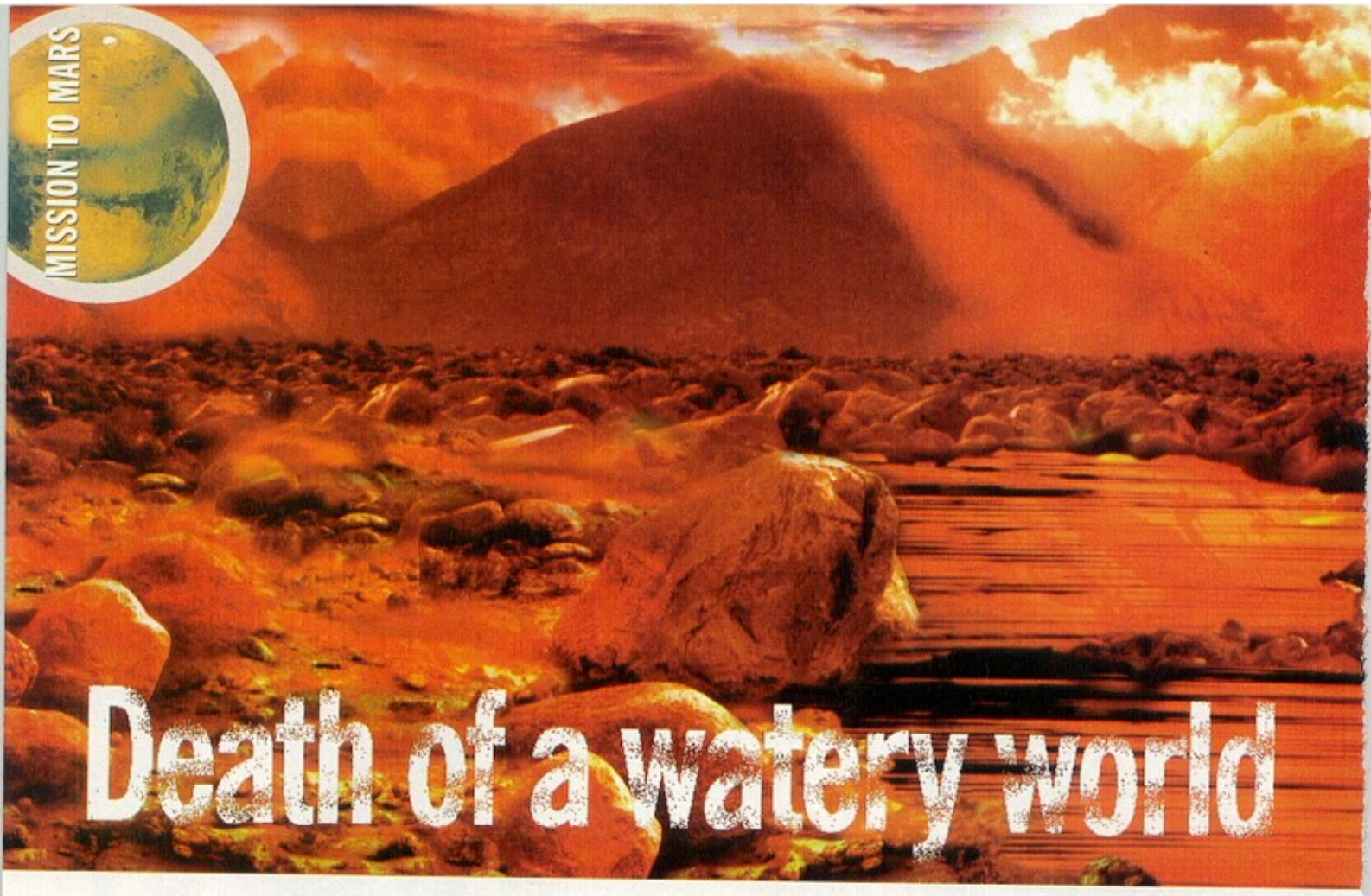
Robert Ballard, Jack Coreliss, and Jack Donnelly dive 2·5 km to the ocean floor in a submarine 8 m long called Alvin. Near the Galápagos Rift, where hot magma surges up from inside the Earth, they discover sulphur-eating bacteria and giant clams that live without light at temperatures over 380°C. The creatures spark new theories about the bare necessities of life

AD 1981-97

The space shuttle fleet (Columbia, Challenger, Discovery, Atlantis, and Endeavour) makes around 90 flights to deploy satellites, fix space stations and telescopes and perform microgravity experiments. One shuttle doesn't make it. Seven lives are lost

AD 2011

Mars?



Death of a watery world

With its next lander, NASA plans to discover what turned Mars from a warm, wet place to the cold, arid planet we see today, reports *Ralph Lorenz*

IN ITS YOUTH the Red Planet was very different from the frozen, barren desert we have seen on our TV screens courtesy of Pathfinder. The winding river valleys, shorelines and flood plains formed in those early times are clearly visible from space: proof that liquid water once flowed on Mars. It must have been warmer, too. And the planet's atmosphere must have been thicker to trap heat from the Sun and create enough pressure to prevent water from boiling away.

So what went wrong? Why did the Martian atmosphere vanish and what happened to the water that once flowed across its surface? Did the planet die from natural causes, or was it a case of suicide, or even murder?

Scientists hope to get some answers from the Mars Global Surveyor spacecraft, which entered orbit around Mars last week. Soon it will be photographing, measuring and studying the surface of Mars. But this is just the beginning of a much longer, more detailed mission. The Surveyor will enter a new phase of operation three years from now as a communications satellite for a Mars lander and two "penetrators" now under construction. Long after it has finished its main mission, the Surveyor will listen for radio signals from the ground, amplify them and retransmit them to Earth.

The mission designed to take advantage of the Surveyor's services—the Mars Volatiles and Climate Surveyor (MVACS)—will be launched in January 1999. It will land at the edge of the southern polar cap of Mars and study the climate, the soil and atmosphere, looking for the telltale evidence that will explain why Mars is now a dead planet.

There are three main theories and together they read like the plot of a detective novel. The first possibility is that Mars was murdered. The surface of Mars is scarred with craters from collisions with comets and asteroids. The blast from such impacts can blow away the atmosphere above the crater. And with enough large impacts, a substantial fraction of the atmosphere could be eroded. It would have been a slow, drawn-out death by suffocation.

Sucked away

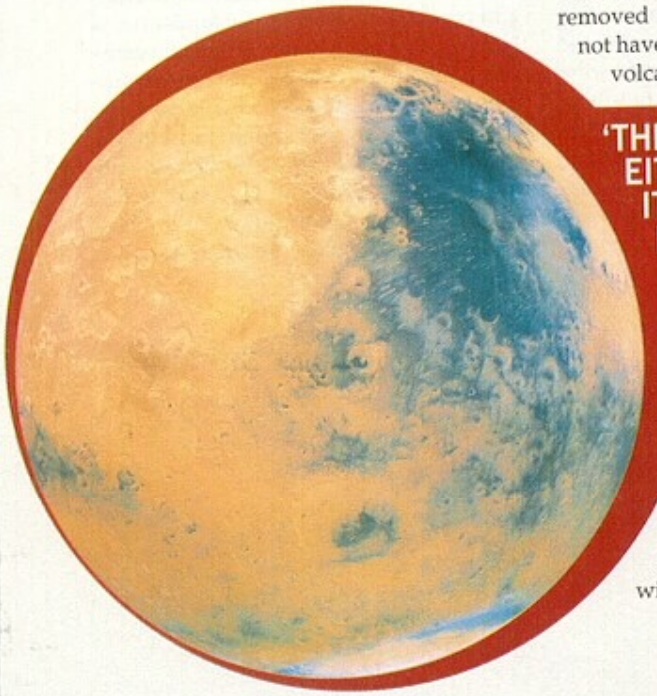
Another possibility is suicide. Mars would have needed a thick atmosphere of a greenhouse gas like carbon dioxide to keep it warm enough for liquid water to flow over its surface. And what little atmosphere it has today is mainly CO_2. Much of its CO_2 may have reacted with Martian silicate rocks to form chemicals called carbonates. If there was no other source of CO_2, the atmosphere would gradually have been sucked into the surface of the planet.

A similar process occurs on Earth, but here there is a carbon cycle to maintain the status quo. CO_2 is removed from the atmosphere by photosynthesis in plants. Carbonates such as limestone or chalk form from the shells of dead sea creatures

Illustrations: Charlie Ward/ US Geological Survey SPL

that fall to the ocean floor, removing their carbon from the cycle. But CO_2 is also pumped back into the atmosphere by volcanic activity. The net effect is that CO_2 levels remain roughly constant.

The evidence for the suicide scenario comes from Martian meteorites that have landed on Earth. Small amounts of carbonates have been found in these rocks, and some scientists believe that this supports the claim that life once existed on Mars. But carbonates can form by purely physical processes too—as in the reaction between CO_2 and silicates—if the conditions are right. Either way, once CO_2 was removed from the atmosphere, it would not have been replaced since Mars is not volcanically active.

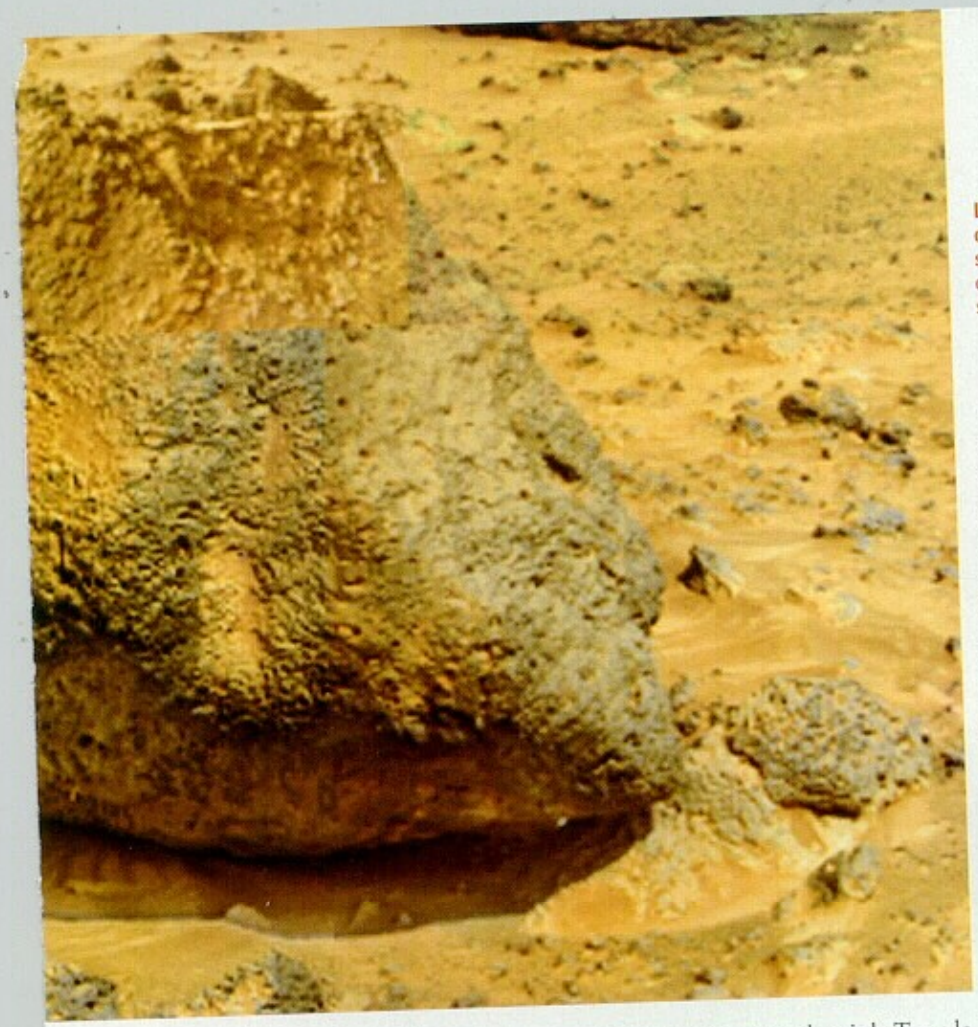


'THERE ARE THREE OPTIONS: EITHER MARS WAS MURDERED, IT COMMITTED SUICIDE, OR IT DIED OF NATURAL CAUSES'

The final possibility is that the Red Planet died of natural causes. Mars has an orbit that is more eccentric than the Earth's, so the amount of sunlight it receives during the year varies hugely. The axis of the planet may also have tilted sharply in the past so that winters were very severe. Combinations of changes in tilt and orbit, the so-called Milankovitch cycles, are believed to be responsible for the onset of ice ages on Earth. Mars may be in the middle of a similar ice age in which much of its CO_2 atmosphere has condensed to form permafrost at the poles or beneath the entire surface. This would be hidden from orbiting spacecraft.

Martian ice ages may be self-perpetuating. A thinner atmosphere would be less effective at transporting heat from the equator to the poles. Because of this, the poles would stay cold, keeping the CO_2 locked up even when a change in the planet's eccentricity and tilt made the winters less severe. This may have locked Mars into a permanent ice age.

The only way to decide which of these scenarios is most likely is to land a craft at the poles, or at least nearby, to look for evidence. This is just what the next mission will do. Images from Mariner 9, which orbited Mars in 1971, and the Viking orbiters from the mid-1970s show strange layered terrain at the edge of



Le choix du terrain pour procéder aux différentes missions de retour d'échantillons sera déterminant. Les chercheurs américains ont présélectionné plus d'une centaine de sites intéressants.

cune de ces missions, de remplir son conteneur de mini-prélèvements de sol, et cela jusqu'à épuisement de ses réserves d'énergie. En 2005, un atterrisseur aurait dû se poser à proximité de l'un des deux robots avant de décoller vers la Terre avec le précieux chargement. Exigeant une précision diabolique, un tel rendez-vous était quasi impossible. La nouvelle mouture apparaît plus réalisable. Cette fois, c'est la sonde retour qui aura la responsabilité de localiser, puis de rattraper, les deux capsules d'échantillons : celle de la mission 2003, en attente depuis deux ans, et celle de 2005.

Si le pari est moins risqué que dans le scénario précédent, cette partie de chasse autour de Mars s'annonce tout de même *"extrêmement sportive"*, prévient Francis Rocard. Le gibier sera constitué d'étuis sphériques de 20 cm de diamètre, placés en orbite avec une précision aléatoire. *"Dans sa version d'origine, celle de la Navy, l'engin qui faisait office de MAV pesait 700 kg et était doté de moteurs cryogéniques,* explique Francis Rocard. *Celui dont nous disposerons est sept fois moins lourd et ses trois moteurs à poudre réduiront très sensiblement la précision de mise en orbite."* Première difficulté, donc : localiser la capsule contenant les échantillons de 2003. La caméra de Mars Express aura, en principe, eu le temps de la repérer et de la suivre. Avec un peu de chance, les antennes du Deep Space Network de la Nasa auront peut-être réussi à capter depuis la Terre le "bip bip" lancé par son émetteur radio. Si tout va bien, les paramètres de son orbite seront donc connus et la chasse pourra commencer.

Les États-Unis pensent déjà à des missions pour 2007-2009, et même au-delà

L'orbiteur traquera son gibier par radio d'abord, puis par navigation optique. En fin d'approche, un système de guidage automatique par laser prendra la relève, jusqu'à ce que le conteneur soit "gobé" par la capsule de rentrée atmosphérique terrestre, fixée sur la sonde. *"Avec de la chance, il nous restera du temps pour récupérer le second conteneur, celui de la mission 2005. Sinon, nous l'abandonnerons,* commente Francis Rocard. *Tout dépendra de la date de lancement car, si la fenêtre de tir en 2005 dure trois semaines, la date de rentrée, elle, est immuable. Si on ne la respecte pas, on manque d'ergols pour le retour."* Pour l'ingénieur du Cnes, la récupération d'un seul conteneur serait déjà un succès. *"C'est une mission ambitieuse et difficile. Un peu l'équivalent du concept Apollo, mais en automatique, mille fois plus loin de la Terre et avec des budgets sans commune mesure."*

Les Américains semblent en tout cas confiants. Ils ont déjà porté sur leur proposition de planning des missions identiques à celles de 2003-2005 pour 2007-2009 et pour 2011-2013. Il est vrai qu'ils ont aussi prévu une solution de repli en cas de défection française. Si Ariane 5 n'est pas disponible, il n'y aura ni atterrisseur ni rover en 2005 et la Delta 3 ne lancera cette année-là que l'orbiteur destiné à récupérer les échantillons de la mission 2003. Mais *a priori*, c'est la version haute, avec le lanceur et la sonde promis par la France, qui prévaut. La Nasa s'est même montrée intéressée par le concept de "micro-missions" proposé par le Cnes. Des sondes de 200 kg (70 kg hors ergols et moteur) qu'Ariane 5 emporterait en passagers supplémentaires lors de tirs commerciaux. Les Américains se disent prêts à réaliser eux-mêmes ces petits engins, dont ils évaluent le coût à 50 millions de dollars pour un modèle unique (35 s'ils sont fabriqués en série). Ils pourraient emporter des expériences (mini-rovers, ballons, etc.) susceptibles de tester les futurs sites d'atterrissage, ou servir de relais de télécommunications en orbite martienne. Ce qui permettrait à la Nasa de réaliser la couverture médiatique sur Internet dont elle rêve pour la mission 2005. Huit de ces micro-missions sont déjà inscrites au planning : deux en 2003, quatre en 2005 et deux en 2007. Reste à les financer.

En attendant, les deux partenaires peaufinent leurs projets et tentent d'accorder leurs rêves à leurs moyens. Côté français, seul l'orbiteur cause encore quelques soucis aux ingénieurs du Cnes. Il s'agit d'une première technologique pour la France et la fourchette de 400 à 800 millions de francs prévue à ce jour pour sa réalisation sera peut-être difficile à respecter. En revanche, le budget de 400 millions de francs affecté aux quatre mini-stations Netlander ne devrait pas être dépassé, estiment les responsables du projet. D'ici là, Français et Américains vont échanger leurs signatures au bas de lettres d'accord et, dans les deux ou trois mois qui viennent, d'un document décrivant dans le détail les tâches des uns et des autres. À première vue, rien ne semble devoir enrayer le cours de cette belle aventure qui marquera l'entrée en force de la France sur la scène martienne. ■

(1) Avec une participation du Centre d'étude des faibles rayonnements, à Toulouse, qui a mis la main à ce spectromètre gamma.